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HEALTH BUILDING NOTE

PATHOLOGY DEPARTMENT

15

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Health Building Note No. 15 (Revised 1973) Reprinted with amendments 1981

NOTE

This building note is a reprint of the 1973 edition amended to take into account the recommendations contained in the 'Code of Practice for the Prevention of Infection in Clinical Laboratories and Post-Mortem Rooms' (The 'Howie' Code of Practice). A full revision of the Note will be prepared in due course.

Pathology Department

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Foreword

This Building Note is a reprint of the 1973 edition (which replaced that published in 1962) amended to take into account the recommendations contained in the 'Code of Practice for the Prevention of Infection in Clinical Laboratories and Post-mortem Rooms' (HMSO 1979) (the 'Howie' Code of Practice) which was the result of the work done by the Working Party set up under the Chairmanship of Sir James Howie. It is proposed to produce a fully revised edition of this Note in due course, but in the meantime this amended reprint has been prepared to ensure that full account is taken of the Code's recommendations in any current planning and design. Where appropriate, cross-references to the relevant paragraph numbers in the Code are given in square brackets.

An Interim Advisory Committee on Safety in Clinical Laboratories has been set up by the Department to review on an interim basis the operation of the Code of Practice and to give advice to the NHS on its implementation. Advice given by the Committee will be collated and issued to the NHS from time to time in the form of a Bulletin, and planning and design teams should take note of any works consequences flowing from this advice.

The recommendations in this Note (apart from those in the Howie Code of Practice) are based on the Final Report of the Departmental Committee on Pathology Design (April 1968), the investigation of user requirements in laboratories carried out for the Greenwich Development Project and also the advice given at the time (1973) by numerous pathologists and laboratory technicians.

Guidance on the provision for radioactive isotope services is not included in this Note, but guidance was issued separately to Regional Hospital Boards in the form of a Departmentally produced Design Guide entitled 'Radioisotope Services' dated October 1973 (subsequently amended by HN(76)72 dated April 1976).

Application of this Note

This Note is intended to be used as planning guidance material and should not be regarded as depicting a standard plan since the organisation of pathology services will need to take into account numerous local variables. The guidance is directed primarily towards the provision of accommodation by new building. It applies equally to existing buildings but where it is found necessary to depart from the guidance, either due to structural constraints or for other reasons, health authorities must satisfy themselves that compliance with the Code of Practice for the Prevention of Infection in Clinical Laboratories and Post-mortem Rooms will still be achieved. In particular, where authorities are faced with a major problem of difficulties in arranging for microbiological safety cabinets to be exhausted to the open air they should consult the Department (Works Group—Directorate of Works Operations Branch 3.1) and the local Health and Safety Executive Inspectorate for consideration of alternative arrangements.

Consultation

The need is stressed for a fully prepared and documented brief for building works and full consultation between the project team and design professionals and those who will be responsible for the operation of the laboratory.

The approval of the Medical Laboratory Technicians Board of the Council for Professions Supplementary to Medicine is required for laboratories used for the training of medical laboratory technicians. The Board should therefore be consulted at an early stage in the planning of new laboratories where junior technicians will be employed. The procedure for approval of training institutions (including laboratories) is described in paragraphs 16 and 18 of the appendix to HM(64)51.

Definitions

It is essential that the proper use and function of the various types of protective enclosures (microbiological safety cabinets, laminar flow cabinets, fume cupboards etc) is fully appreciated (see para 20(b)). Where such an item is mentioned in this Note the appropriate definition listed below shall be taken to apply. (Definitions (i), (ii) and (iii) below are taken from the Howie Code of Practice, para 24—see also BS 5726: 1979 Specification for Microbiological Safety Cabinets.)

i. Microbiological Safety Cabinets

(a) *Class I.* Open-fronted exhaust protective cabinets. These offer adequate protection to the worker against the inhalation of aerosols containing Category B1 organisms, viruses and materials. This kind of cabinet is usually fitted in hospital microbiological laboratories. The protection offered by these cabinets depends on correct installation and maintenance. [24(a)(i)]

(b) *Class II.* Vertical laminar flow cabinets of special design. These recirculate some filtered air, exhaust some to atmosphere and take in replacement air through the open front. There are various designs. All offer protection from contamination to the material handled and some protection to the worker, depending on design and maintenance. They are mainly used in tissue culture work. Until further assessment has been made Class II cabinets must not on any account be used for handling potentially tuberculous material or organisms in Categories A and B1. They may be used for testing for hepatitis B surface antigen, where the risk of inhalation of aerosols is not great and for work with tissue cultures not involving viruses in Categories A and B1. A notice must be displayed on such cabinets forbidding their use for Category A and B1 organisms, agents and materials. [24(a)(ii)]

(c) *Class III.* Totally enclosed exhaust protective cabinets which are gas-tight and fitted with glove ports. They are used for handling Category A organisms and viruses when complete isolation of work from worker is required. A high standard of maintenance is essential. [24(a)(iii)]

ii Horizontal laminar flow cabinets (outflow)

These are designed to protect the work from contamination. A stream of filtered air passes from the rear of the cabinet across the workbench towards the worker. These are NOT safety cabinets and must not be used for handling any pathological materials or cultures of any micro-organisms. They must not be used for mammalian tissue-culture work in clinical laboratories where such tissue cultures may contain viruses other than those with which they have been inoculated. Any aerosols liberated during manipulations are directed at the face of the worker. [24(a)(iv)]

iii. Vertical laminar flow cabinets (other than Class II)

Protect the work but not the worker. The risks to the worker are similar to those in (ii) above: infected material is returned unfiltered to the room and may be inhaled. [24(a)(v)]

iv. Laboratory Fume Cupboard

A partial enclosure with a mechanical means of efficient air extraction such as a fan and an adjustable protective screen of safety glass. It may be equipped with services such as gas, water and electricity. Fume cupboards are required for work with materials which generate fumes, gases, vapours and dusts which must not be released into the laboratory environment, eg evaporation, distillation, digestion, radioactive work, work with carcinogens, use of aerosol sprays, and dispensing of chemicals. Some of these applications require special design, construction and air flows eg use of perchloric acid (see HN(76)95), ionising radiations (see Ionising Radiations—Unsealed Radioactive Substances Regulations 1968), and spraying of chemicals in the laboratory (see HN(78)36). Fume cupboards used for dispensing of chemicals may include a ventilated storage cabinet. The protection offered by fume cupboards depends on correct installation and adequate maintenance.

v. Fume Hood/Canopy

A simple canopy with mechanical means or which utilises convection current for extraction of fumes generated by equipment such as flame photometers. (See CIBS Guide Books B2, B3.)

I. Scope

Area pathology laboratories.

1. This Building Note gives general guidance on the provision of area pathology laboratories.

Public Health Service laboratories

2. This Note also gives guidance on the provision of those Public Health Service laboratories which are to be integrated within major hospital laboratories.

Mortuary and post-mortem facilities

3. These should be considered when making provision for pathology laboratories. The post-mortem room should generally form part of the laboratory complex and is usually located adjacent to the laboratory, though it can be positioned elsewhere on the hospital site while remaining the responsibility of the pathologist. Guidance on design is given in Hospital Building Note 20: Mortuary and Post-mortem Room.

Teaching hospital laboratories

4. This Note makes only brief reference to the clinical work of Teaching Hospitals laboratories. It does not aim to describe their design, though the principles embodied within these recommendations should apply to them also.

Animal houses

5. The requirement for and sizes of animal houses should be assessed for each individual case as they will vary depending on the types of test carried out, the type and number of animals used and the facilities in adjacent hospitals. Close liaison should be maintained with the Home Office Inspector who must certify on completion that the animal house accommodation is adequate for its purpose.

Department of Physical Sciences

6. This Note does not contain information relating to a department of physical sciences to which reference is made in the report of the Committee on Hospital Scientific and Technical Studies under the Chairmanship of Sir Solly Zuckerman. Further guidance on this aspect will be issued if necessary when the full implications of the report have been assessed.

II. General aspects

Purpose of service

7. The planning of pathology laboratories as subsequently described is related to a general policy of planning diagnostic laboratories to meet the needs of general practitioners, local authority clinics and health centres in addition to the hospitals with which the laboratories are associated. The pathology laboratory receives requests for tests together with the associated specimens taken from in-patients, out-patients ,or patients outside the hospital. Laboratory tests are carried out on the specimens and the results of the tests returned to the originators of the requests. Information in the reports is used as an aid to diagnosis or treatment.

Extent of service and application in particular circumstances

8. It is anticipated that laboratory service development within each Region will tend toward the establishment of two types of laboratory, described in these recommendations as Area Pathology Service and Satellite Pathology Service Laboratories. Demographic factors may exist which will make it desirable to provide supplementary space within an enlarged area laboratory for certain non-urgent activities and special reference work from other laboratories. Some area laboratories will include a joint microbiological department with the Public Health Laboratory Service, the latter serving a wider catchment area than the rest of the laboratory. The application of these recommendations varies according to local circumstances, geographical factors and particular planning situations. Operational conditions and constraints, which will vary from place to place, may include items such as staffing, level of equipment, existing facilities, travel distances, and traffic conditions.

Area pathology service laboratories

9. These are defined as laboratories designed to serve a population of at least 200,000 and providing a comprehensive service in the departments of:

Morbid anatomy (including, if local arrangements permit, forensic pathology)

Haematology (including blood transfusion)

Chemical pathology (including toxicology)
Microbiology (including parasitology)

10. A comprehensive laboratory division may be expected to include the following associated sub-departments:

(a) Morbid anatomy	histopathology, cytology
(b) Haematology	general haematology, serology, mechanised section, blood transfusion
(c) Chemical pathology	general biochemistry, mechanised section
(d) Microbiology	clinical microbiology (The workload as currently seen is insufficient to justify a designated virology sub-department at every area laboratory. The space allocated in a joint hospital/ P.H.L.S. microbiology department includes provision for a degree of special interest in virology. More comprehensive facilities for virological work will be provided at Regional P.H.L.S. laboratories and in other specialist centres by Regional Health Authorities and Teaching Hospitals. Nevertheless some space has been allowed in this Building Note for the undertaking of simpler virology tests using 'bought-in' culture materials should local circumstances demand it).

In a typical area laboratory each of the above main departments will be under the direction of a consultant pathologist. One of these consultants will undertake the administrative responsibility for running the area service as a whole. The main departments will be fully operative during normal working hours and an emergency service, provided by staff on stand by or on call, will be available at all times.

Satellite pathology service laboratories

11. These are less readily definable since they may vary considerably as regards the extent of service provided, depending on their location and relation to an area laboratory. They should be part of the area laboratory service and will not, by definition, aim to provide a comprehensive service. They would be located in peripheral hospitals and their function should be to meet the demand for urgent investigations (electrolytes, cerebro-spinal fluids, etc.) which cannot be expected to wait upon transport to an area laboratory. Satellite laboratories should be within a convenient distance of area laboratories e.g. an approximate limit of 20 miles or one hour travelling time from an area laboratory whichever is less. Each case will need to be assessed on its own merits as access to a motorway may enable the travel distances to be extended, whereas in urban or other areas (e.g. holiday resorts) which are subject to traffic congestion lower limits may be required.

Sub-Regional/Regional reference laboratories

12. As indicated in paragraph 8 some area laboratories will need to be enlarged to provide reference facilities for the less common techniques in pathology, some as autonomous departments. They would include one or more of the functions listed below. At present each of these disciplines is normally covered by consultants in other departments, but the rate of growth is such that many of them will need to be specially staffed. *The functions of reference laboratories as indicated are not exhaustive and other functions may similarly need more space than that provided on an area laboratory basis.*

(a) Cytology

Every comprehensive area laboratory should include a sub-department of cytology. It is also considered desirable that enlarged reference centres be established at strategic point(s) in each region.

(b) Trace elements and toxicology

It is probable that only a very limited amount of trace element work and toxicology will be undertaken at area laboratories, the bulk of requests being sent to Sub-Regional centres.

(c) Immunology/serology

This is a growth point of routine pathology which may well become an independent department in the future. Whilst every area laboratory can be expected to undertake serology (microbiological and haematological), selected laboratories should be allocated additional accommodation in which to act as reference centres.

(d) Chromosomes (genetics)

At present this function is generally carried out in Teaching Hospitals. In order to provide an adequate service in the future at least one Sub-Regional reference centre should be provided within each regional hospital network.

(e) Neuropathology

Similar considerations as those indicated for chromosomes (genetics) apply.

(f) Research facilities

Where it is proposed to establish special laboratory facilities for clinical research these should be located within the laboratory complex and not in association with clinical departments since the latter practice can lead to staffing problems. These facilities should be on a planned basis in each region according to requirements.

Public Health Laboratory Service

13. Where it is proposed to establish a joint area P.H.L.S. and area hospital laboratory (with different catchment areas) to carry out microbiological and virological work the primary space allocation for microbiology in the area laboratory is increased as in Table 2. The responsibility of the P.H.L.S. is limited to England and Wales. In Scotland the work undertaken by the P.H.L.S. is carried out in the laboratories provided by the Regional Health Authorities, so that in using this Building Note in Scotland this factor should be taken into account in determining the requirements of hospital laboratories.

Statement of demand and provision for future trends

14. The demand for pathology tests has been increasing rapidly and continuously during recent years. The annual increase in workload (i.e. tests carried out in the laboratory) has been shown to be in the order of 10 per cent per annum overall. For individual departments such as chemical pathology and haematology the increase has been in the order of 15-20 per cent per annum. As well as an increase in the workload the range of special tests has increased.

15. Local circumstances will determine the demand to be catered for in each particular case, and also the provision to be made to meet any anticipated increase in workload. Methods by which production could be increased without the need for additional space would include further mechanisation (including miniaturisation) and automation.

Supporting services

16. This Note allows for the inclusion within the laboratory of certain elements of general accommodation that, by the ingenuity of the whole-hospital planner, may alternatively be combined with similar facilities elsewhere. These facilities could include supply and disposal systems, maintenance and administration. Such integration would achieve economies in staff and space.

Communication links

17. As pathology is mainly an indirect service to patients on an area basis adequate external as well as internal communication lines should be provided.

Specimens

18. Most of the work coming to an area laboratory will arrive as pathology specimens from the following sources:

Outside the hospital (requiring an external transport service)

(a) Outlying small hospitals and satellite laboratories.
(b) General practitioners.
(c) Local authority clinics.
(d) Health centres.
(e) Public Health Inspectors.

Inside the hospital

(f) Out-patient department.
(g) Accident and emergency department.
(h) Operating theatres and intensive care unit.
Planning or other provision will have to be made to satisfy the need that will arise in these areas for urgent testing and reporting back.
(j) Wards.
Some wards have a heavier demand for pathology tests than others. Consultant pathologists may be called in to give advice in wards, and laboratory staff may provide a specimen collection service to the wards.
(k) Post-mortem room.
Specimens from this area will be delivered to the morbid anatomy laboratory; some will also be sent to chemical pathology and possibly microbiology.

People

(l) Suitable access will be required for patients who need to attend the laboratory in person on referral either by hospital staff or general practitioners. There should be a direct connection between the laboratory entrance and the reception office area. The specimen reception area must be separated from clerical offices or public corridors. The specimen reception counter should be separate from that used for patient reception. (See para 26(c).) Blood must not be taken from any patient or member of staff in any room used as a laboratory room. [12, 14] The consulting/examination rooms should be closely associated with this area and with the departments of haematology and biochemistry. Doctors from the hospital and general practitioners will be encouraged to visit the laboratory regularly. Where there is a Public Health Laboratory Service element at an area laboratory the microbiology department should be easily accessible to the local authory officers etc. whom the department serves.

Supply and disposal

19. The need to allow for the receipt of bulk deliveries of chemicals and large items of equipment will influence planning decisions on the size and position of lifts, hoists, corridors and storage rooms. The treatment and disposal of laboratory materials and specimens will be carried out in accordance with paragraph 18 of the Howie Code of Practice. A space inaccessible to the public and having easy access to disposal routes to the incinerator area should be provided to hold material, possibly contaminated, pending removal to the incinerator—see paragraph 59(g). [18b (ii)]

Operational methods

20.(a) A wide variety of methods is available for carrying out pathology tests. These include manual, mechanised and automated techniques. In this context mechanisation means the use of automatic analysing equipment whereas automation denotes the linking to it of automatic data processing and electro-mechanical transmission equipment. The methods adopted in particular situations will depend on a variety of factors. The different methods used for carrying out tests will have different implications on the space requirements, staffing, equipment and layout. Paragraphs 21 to 26 give a description of the general work pattern which might be expected in each department of an area laboratory together with a simple functional diagram for each department. The functional diagrams are intended to illustrate solely how a department *could* operate; they are not intended to indicate the exact way in which a department should operate. There can be variation to the workflow in particular laboratories which will depend on the methods adopted or preferred for carrying out tests and the degree of mechanisation or automation.

(b) Microbiological safety cabinets

Clarification of the terminology applied to define types and functions of microbiological safety cabinets, laminar flow cabinets, fume cupboards and protective hoods is a paramount need and reference should be made to the list of definitions given under the Foreword of this Note. Attention is also drawn to paragraph 24(a) of the Howie Code of Practice and to the British Standard Specification for Microbiological Safety Cabinets, (BS 5726: 1979), which describe the three classes of microbiological safety cabinets, and in particular the Class I, exhaust protective cabinet type suitable for fitting in hospital laboratories. There are several types of the latter category available commercially which have been evaluated by the Department and information about these can be obtained from the General Sciences Group I, Scientific and Technical Branch 3A at 14 Russell Square, London WC1 (Tel 01-636 6811). Adequate routine testing, maintenance and servicing is imperative—see Appendix 9 of the Code of Practice. Appendix 14 of the Code of Practice, the Public Health Laboratory Service Monograph No 6, (the Prevention of Laboratory Acquired Infection 1974, Revised 1977, London: HMSO) and BS 5726 give advice on the siting of such cabinets with relevant factors in respect of room ventilation.

(c) The correct use, installation, disinfection, testing and maintenance of microbiological safety cabinets (Class I) (as opposed to other types of cabinet, eg some Class II cabinets and laminar flow cabinets that do not protect the operator, or fume cupboards) is fully documented in paragraph 24, and Appendices 9 and 14 of the Code of Practice, and in BS 5726. Reference should be made to these documents for appropriate guidance.

(d) Where possible shakers, homogenisers and tissue grinders used for Category B1 or B2 micro-organisms, agents and materials must be operated and opened in a microbiological safety cabinet (Class I). When centrifuging Category B1 or B2 material sealed buckets must be used and they must be opened in a microbiological safety cabinet (Class I). [19, 20]

(e) Fume cupboards

A laboratory fume cupboard is a partial enclosure with a mechanical means of efficient air extraction such as a fan and an adjustable protective screen of safety glass. It may be equipped with services such as gas, water and electricity; these and the materials of construction should be resistant to the chemicals handled. Fume cupboards are required for work with materials which generate fumes, gases, vapours and dusts which must not be released into the laboratory environment, eg evaporation, distillation, digestion, radioactive work, work with carcinogens, use of aerosol sprays, and dispensing of chemicals. Some of these applications require special design, construction and air flows eg use of perchloric acid (see HN(76)95), ionising radiations (see Ionising Radiations—Unsealed Radioactive Substances Regulations 1968), and spraying of chemicals in the laboratory (see HN(78)36). Fume cupboards used for dispensing of chemicals may include a ventilated storage cabinet. The protection offered by fume cupboards depends on correct installation and adequate maintenance.

(Note: A fume cupboard is not a microbiological safety cabinet as defined by BS 5726 and paragraph 24 of the Code of Practice and must not be used as such; neither is it a fume hood which is a simple canopy with mechanical means, or which utilises convection current, for extraction of fumes generated by equipment such as flame photometers.)

(f) Warning notices

A warning notice 'DANGER OF INFECTION' within the international 'Biohazard' symbol must be clearly displayed on the doors of all rooms and equipment used for processing, containing or transporting Category B1 organisms, as required by the Code of Practice [11(g) and Appendix 6.]. Exhaust ducting from microbiological safety cabinets must display the international 'Biohazard' symbol so that it is clearly apparent to maintenance staff. Additional notices should be displayed where considered necessary.

Morbid anatomy department—functions

21. Morbid anatomy is the study by dissection of the diseased human body. This department will normally include the following sub-departments:

(a) Histopathology

Histopathology is the study of the microscopic structure of diseased tissues. The majority of specimens are received in jars of formalin, but some larger items may arrive unfixed. Specimens are dissected and passed through automatic tissue processing machines overnight, following which they are blocked in paraffin wax prior to section cutting. When hardened, the wax blocks are cut into sections which are transferred to slides and then stained. After drying, coverslipping and labelling the slides are passed to the consultant together with appropriate report forms for microscopic examination and reporting.

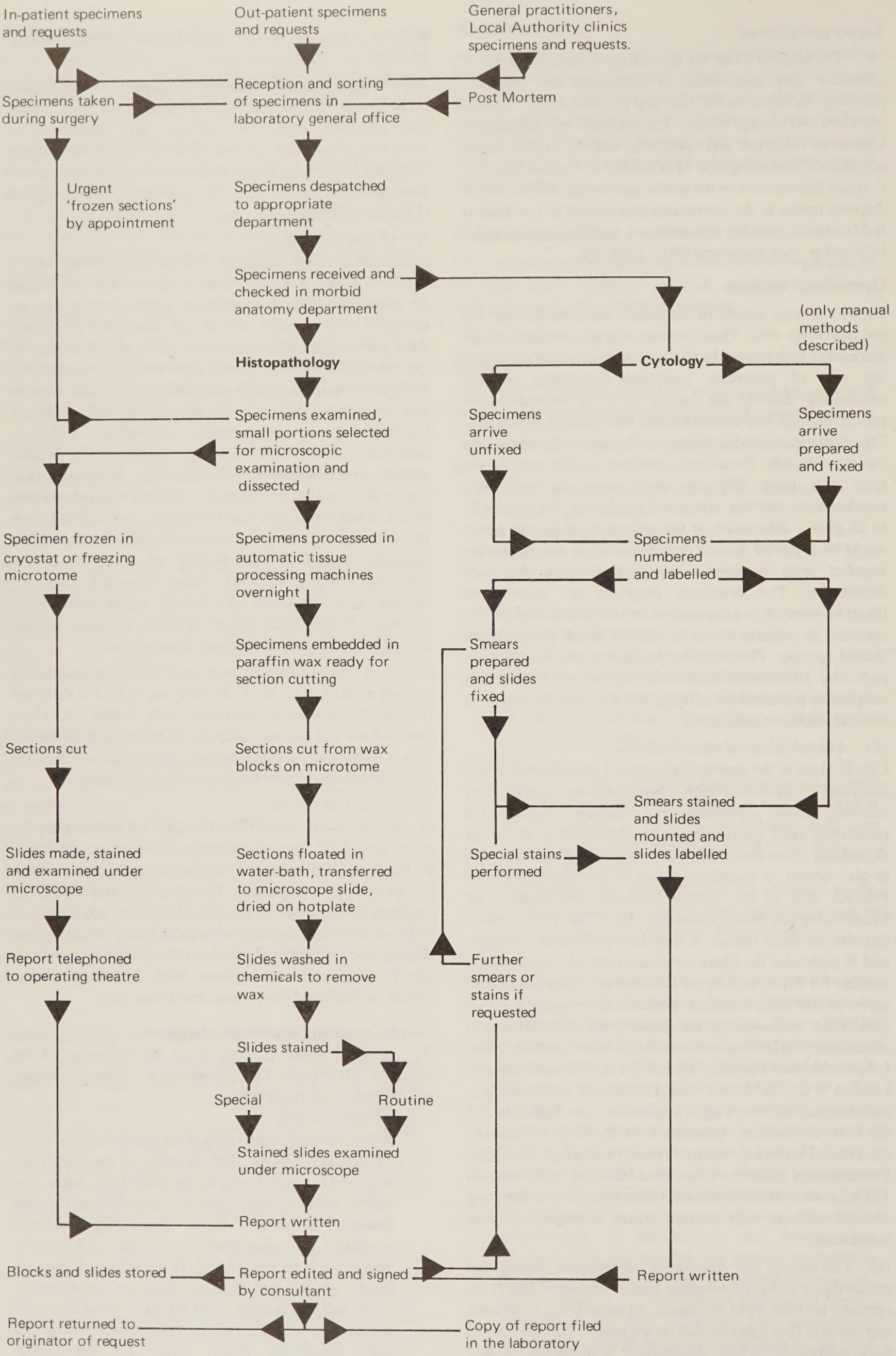

In-patient specimens and requests
Out-patient specimens and requests
General practitioners, Local Authority clinics specimens and requests.
Reception and sorting of specimens in laboratory general office
Post Mortem
Specimens taken during surgery
Urgent 'frozen sections' by appointment
Specimens despatched to appropriate department
Specimens received and checked in morbid anatomy department
Histopathology
Cytology
(only manual methods described)
Specimens arrive unfixed
Specimens arrive prepared and fixed
Specimens examined, small portions selected for microscopic examination and dissected
Specimens numbered and labelled
Specimen frozen in cryostat or freezing microtome
Specimens processed in automatic tissue processing machines overnight
Smears prepared and slides fixed
Specimens embedded in paraffin wax ready for section cutting
Sections cut
Sections cut from wax blocks on microtome
Smears stained and slides mounted and slides labelled
Special stains performed
Slides made, stained and examined under microscope
Sections floated in water-bath, transferred to microscope slide, dried on hotplate
Report telephoned to operating theatre
Slides washed in chemicals to remove wax
Further smears or stains if requested
Slides stained
Special
Routine
Stained slides examined under microscope
Report written
Blocks and slides stored
Report edited and signed by consultant
Report written
Report returned to originator of request
Copy of report filed in the laboratory

FIGURE 1 Functioning of Morbid Anatomy Department

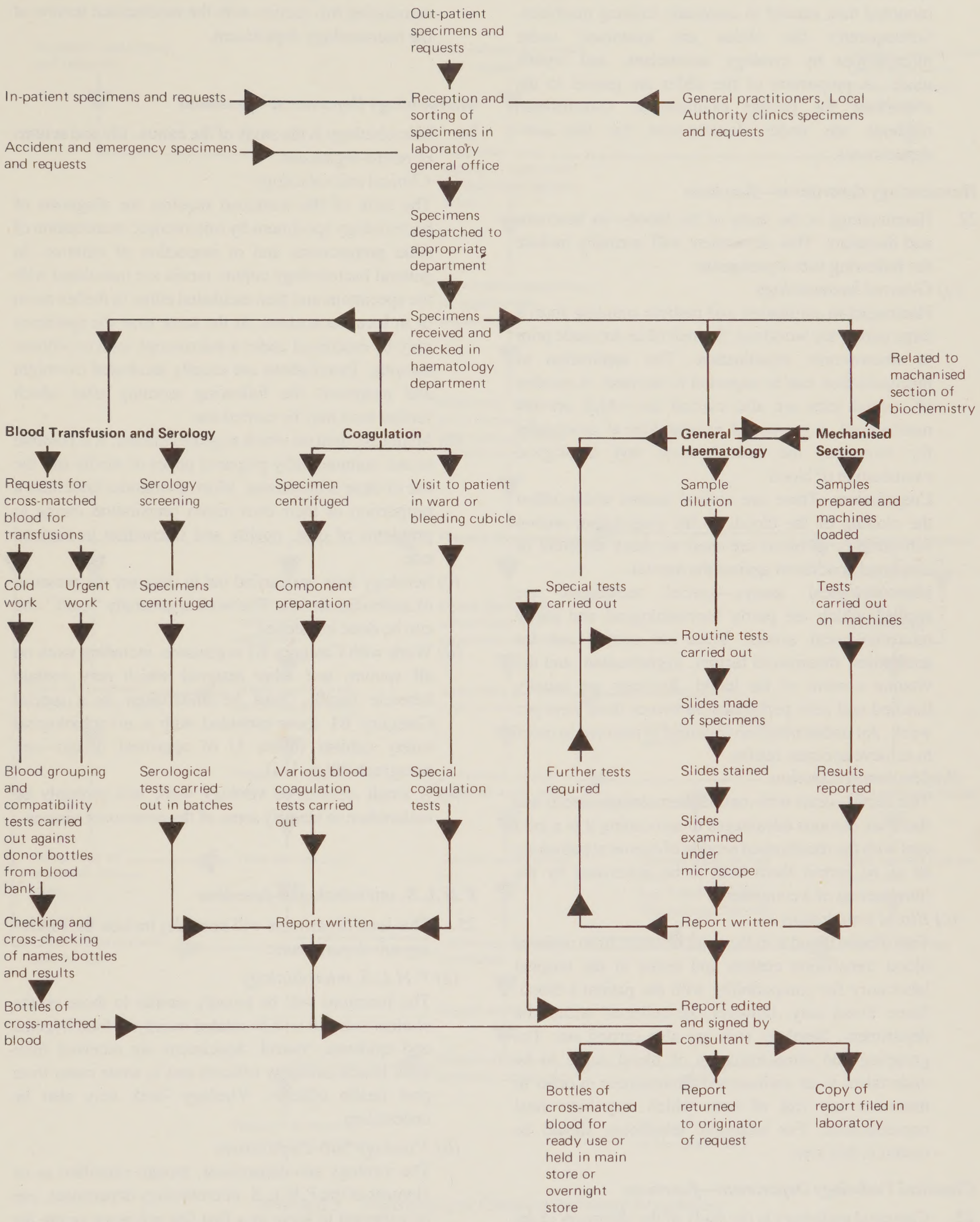

Out-patient specimens and requests
In-patient specimens and requests
Reception and sorting of specimens in laboratory general office
General practitioners, Local Authority clinics specimens and requests
Accident and emergency specimens and requests
Specimens despatched to appropriate department
Specimens received and checked in haematology department
Related to machanised section of biochemistry
Blood Transfusion and Serology
Coagulation
General Haematology
Mechanised Section
Requests for cross-matched blood for transfusions
Serology screening
Specimen centrifuged
Visit to patient in ward or bleeding cubicle
Sample dilution
Samples prepared and machines loaded
Cold work
Urgent work
Specimens centrifuged
Component preparation
Special tests carried out
Routine tests carried out
Tests carried out on machines
Slides made of specimens
Blood grouping and compatibility tests carried out against donor bottles from blood bank
Serological tests carried out in batches
Various blood coagulation tests carried out
Special coagulation tests
Further tests required
Slides stained
Results reported
Slides examined under microscope
Checking and cross-checking of names, bottles and results
Report written
Report written
Bottles of cross-matched blood
Report edited and signed by consultant
Bottles of cross-matched blood for ready use or held in main store or overnight store
Report returned to originator of request
Copy of report filed in laboratory

FIGURE 2 Functioning of Haematology Department

(b) Cytology

Cytology is the study of individual cells shed from the surface of an organ to arrive at a diagnosis. Specimens are received and recorded. A proportion of the specimens may already be mounted; if not they are mounted then stained in automatic staining machines. Subsequently the slides are examined under microscopes by cytology technicians, and reports made. A proportion of the slides are passed to the consultant for further examination. (Mechanised methods are under development for this sub-department).

Haematology department—functions

22. Haematology is the study of the blood—its functions and disorders. This department will normally include the following sub-departments:

(a) General haematology

Haemaglobin estimation and particle counting form a large part of the workload. Stained films are made prior to microscopic examination. The application of mechanisation can be expected to increase. A number of special tests are also carried out which are not mechanised, e.g. special haematological procedures for enzymes, the histochemical and serological examination of blood.

Coagulation—There are several factors which affect the clotting of the blood. In the coagulation section sub-samples of blood are used to check different or abnormal conditions against the normal.

Microbiological assays—special techniques are applied which are partly haematological and partly microbiological assays. Tests are carried out for antibodies, rheumatoid factors, agglutination, and the vitamin content of the blood. Requests are usually batched and tests performed on two or three days per week. An undisturbed environment is required in order to achieve accurate results.

(b) Mechanised section

This section deals with routine haematological tests and there are obvious advantages in associating it in a joint unit with the mechanised section of chemical pathology so as to permit them both to be automated by the introduction of a computer.

(c) Blood transfusion

Transfusion blood is in the main received from regional blood transfusion centres and tested at the hospital laboratory for compatibility with the patient's blood. Some blood may, however, be collected within the department. Serology tests are also carried out. The grouping and cross-matching of blood needs to be undertaken in an undisturbed environment in order to minimise any risk of error which may have fatal consequences. For example, telephones should be muted in this area.

Chemical Pathology Department—functions

23. Chemical pathology is the study of the chemistry of the living tissues and fluids of the body. This department will normally include the following sub-departments:

(a) General biochemistry

All the non-mechanised tests, both routine and special, of biochemistry are carried out within this sub-department.

(b) Mechanised section

This section will deal with routine biochemical tests. Some 80 per cent of routine biochemistry can be undertaken on mechanised equipment. For the reasons stated in paragraph 22*(b)* there are advantages in associating this section with the mechanised section of the haematology department.

Microbiology Department—functions

24. Microbiology is the study of the nature, life and actions of micro-organisms.

(a) Clinical microbiology

The bulk of the workload requires the diagnosis of bacteriology specimens by microscopic examination of slide preparations and of inspection of cultures. In general bacteriology culture media are inoculated with the specimens and then incubated either in the hot room or in local incubators. At the same time the specimen may be examined under a microscope with or without staining. Inoculations are usually incubated overnight and examined the following morning after which further tests may be carried out.

(b) Media are used on which to grow cultures. It is possible to use commercially prepared plates of media and the use of these is increasing. Most laboratories undertake a proportion of their own media preparation owing to problems of cost, quality and fluctuation in demand rate.

(c) Serology tests are carried out to discover the presence of antibodies in sera. The work is generally ''cold'' and can be done in batches.

(d) Work with Category B1 organisms, including work on all sputum and other material which may contain tubercle bacilli, must be undertaken in a special Category B1 room provided with a microbiological safety cabinet (Class 1) of approved design—see paragraph 49(d). [11]

(e) A small amount of virology work will probably be undertaken to identify some of the commoner viruses.

P.H.L.S. microbiology—functions

25. This joint department will normally include the following sub-departments.

(a) P.H.L.S. microbiology

The functions will be broadly similar to those on the clinical side but will be related mainly to food hygeine and epidemic control. Specimens are received from local health authority officers and in some cases from port health officers. Virology work may also be undertaken.

(b) Virology Sub-Department

The virology sub-department, though classified as an element of the P.H.L.S. microbiology department, can be expected to serve as a first line reference centre for those hospital requirements which cannot be met by the more limited virology facilities provided at all area laboratories. More comprehensive facilities for virological work will be provided at Regional Public Health Laboratories and in other specialist centres by Regional Health Authorities and Teaching Hospitals.

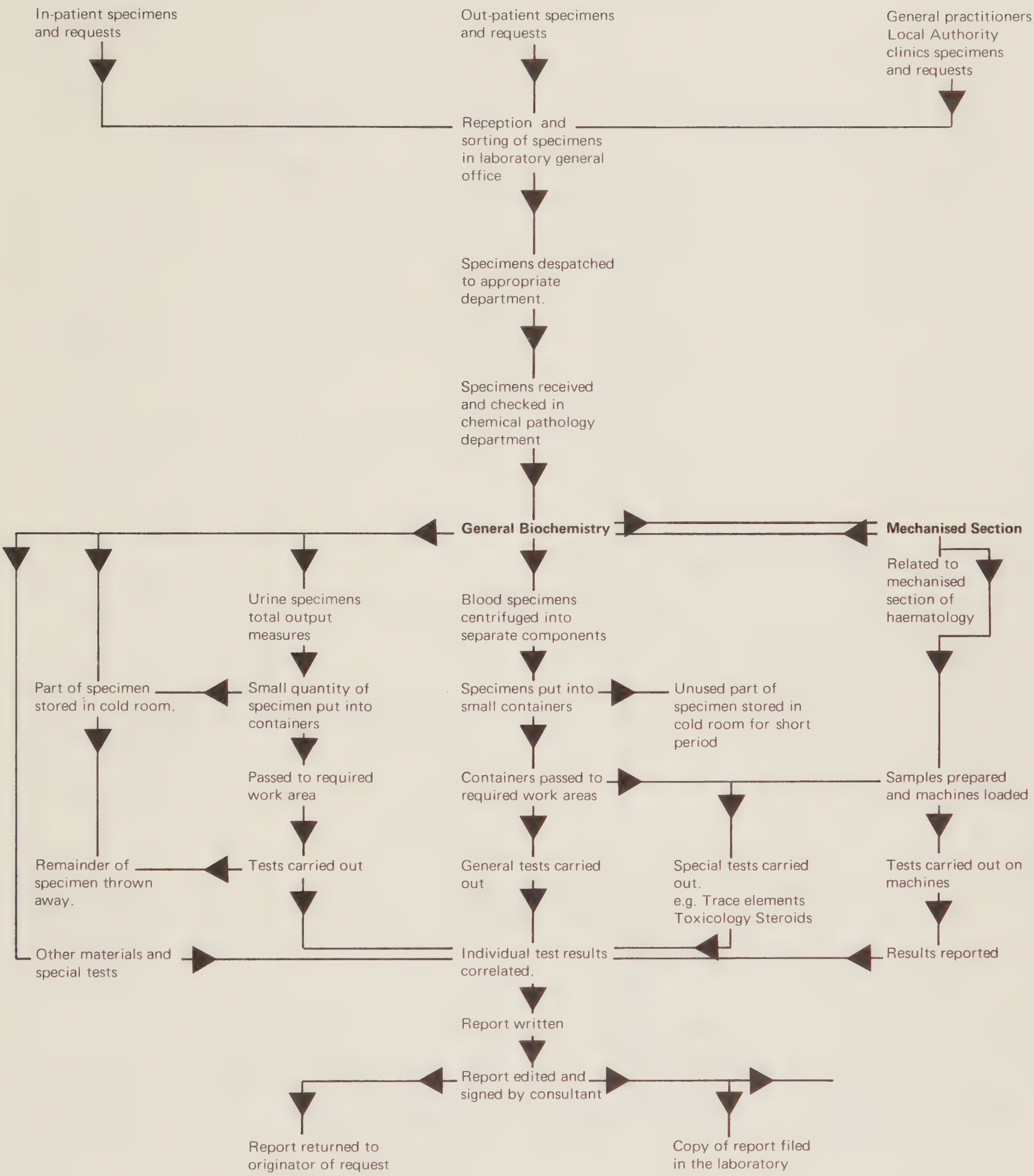

In-patient specimens and requests
Out-patient specimens and requests
General practitioners, Local Authority clinics specimens and requests
Reception and sorting of specimens in laboratory general office
Specimens despatched to appropriate department.
Specimens received and checked in chemical pathology department
General Biochemistry
Mechanised Section
Related to mechanised section of haematology
Urine specimens total output measures
Blood specimens centrifuged into separate components
Part of specimen stored in cold room.
Small quantity of specimen put into containers
Specimens put into small containers
Unused part of specimen stored in cold room for short period
Passed to required work area
Containers passed to required work areas
Samples prepared and machines loaded
Remainder of specimen thrown away.
Tests carried out
General tests carried out
Special tests carried out.
e.g. Trace elements
Toxicology Steroids
Tests carried out on machines
Other materials and special tests
Individual test results correlated.
Results reported
Report written
Report edited and signed by consultant
Report returned to originator of request
Copy of report filed in the laboratory

FIGURE 3 Functioning of Chemical Pathology Department

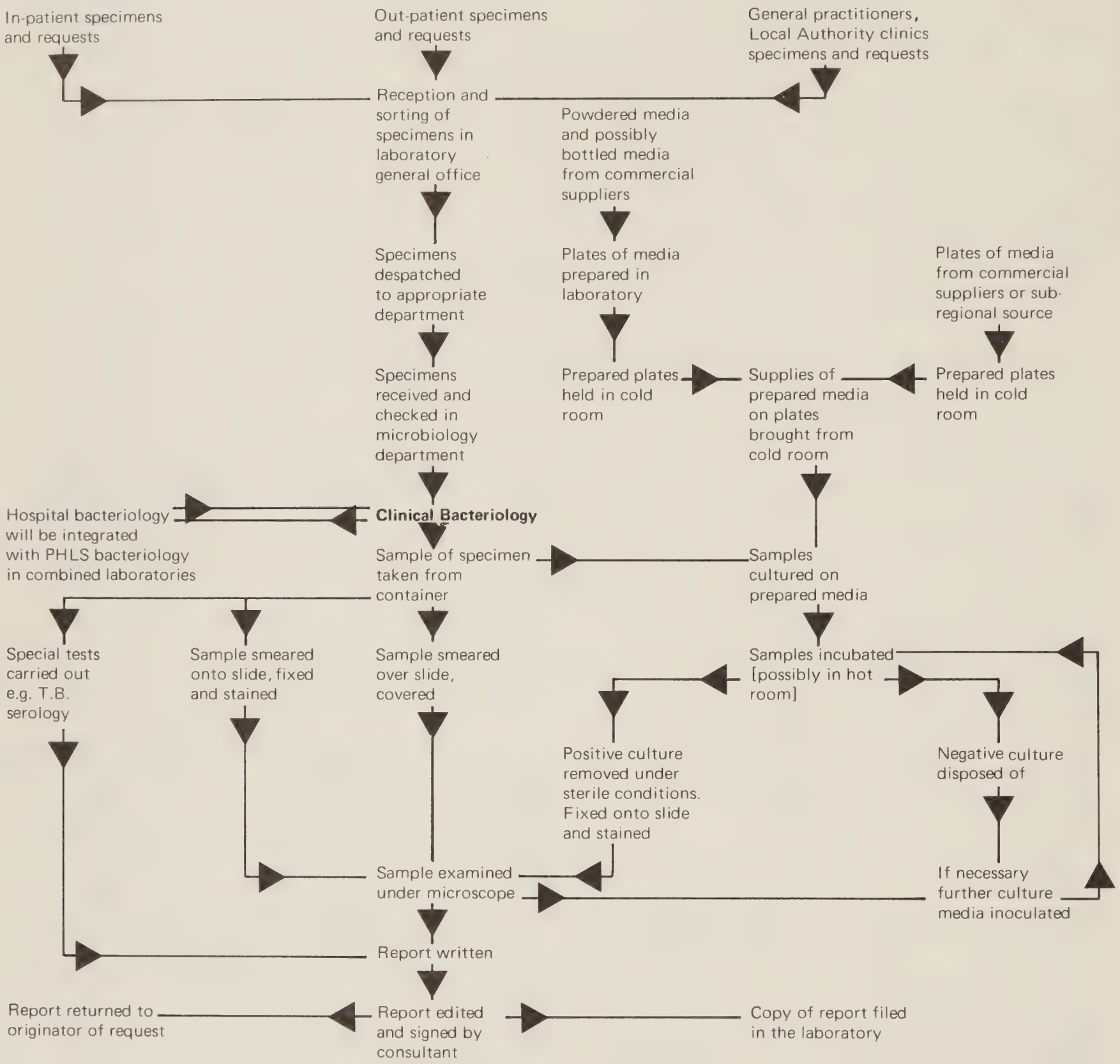

In-patient specimens and requests
Out-patient specimens and requests
General practitioners, Local Authority clinics specimens and requests
Reception and sorting of specimens in laboratory general office
Powdered media and possibly bottled media from commercial suppliers
Specimens despatched to appropriate department
Plates of media prepared in laboratory
Plates of media from commercial suppliers or sub-regional source
Specimens received and checked in microbiology department
Prepared plates held in cold room
Supplies of prepared media on plates brought from cold room
Prepared plates held in cold room
Hospital bacteriology will be integrated with PHLS bacteriology in combined laboratories
Clinical Bacteriology
Sample of specimen taken from container
Samples cultured on prepared media
Special tests carried out e.g. T.B. serology
Sample smeared onto slide, fixed and stained
Sample smeared over slide, covered
Samples incubated [possibly in hot room]
Positive culture removed under sterile conditions. Fixed onto slide and stained
Negative culture disposed of
Sample examined under microscope
If necessary further culture media inoculated
Report written
Report returned to originator of request
Report edited and signed by consultant
Copy of report filed in the laboratory

FIGURE 4 Functioning of Microbiology Department

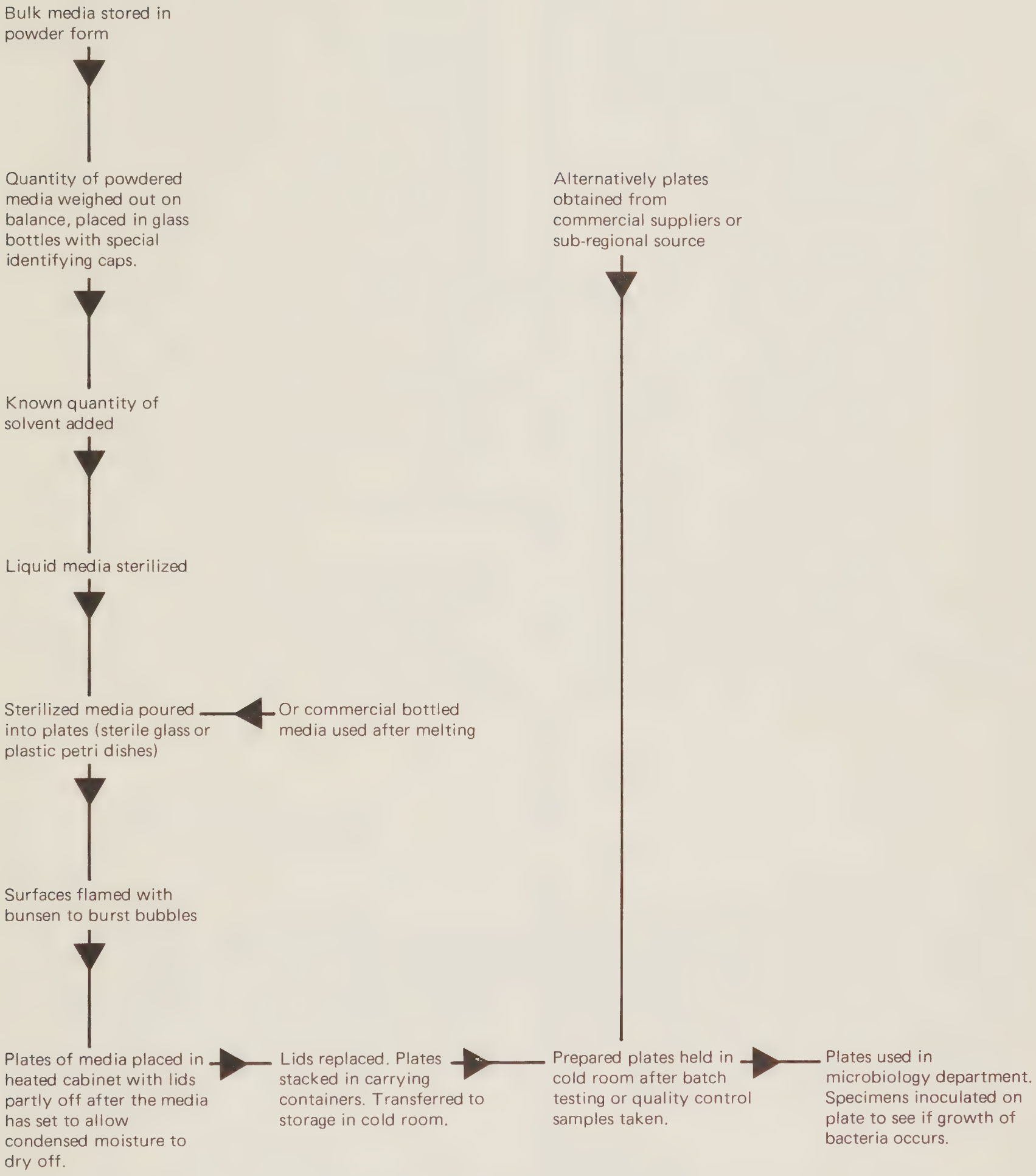

Bulk media stored in powder form
Quantity of powdered media weighed out on balance, placed in glass bottles with special identifying caps.
Known quantity of solvent added
Liquid media sterilized
Sterilized media poured into plates (sterile glass or plastic petri dishes)
Or commercial bottled media used after melting
Surfaces flamed with bunsen to burst bubbles
Plates of media placed in heated cabinet with lids partly off after the media has set to allow condensed moisture to dry off.
Lids replaced. Plates stacked in carrying containers. Transferred to storage in cold room.
Alternatively plates obtained from commercial suppliers or sub-regional source
Prepared plates held in cold room after batch testing or quality control samples taken.
Plates used in microbiology department. Specimens inoculated on plate to see if growth of bacteria occurs.

FIGURE 5 Functioning of Microbiology Department: Media Preparation and Plate Pouring

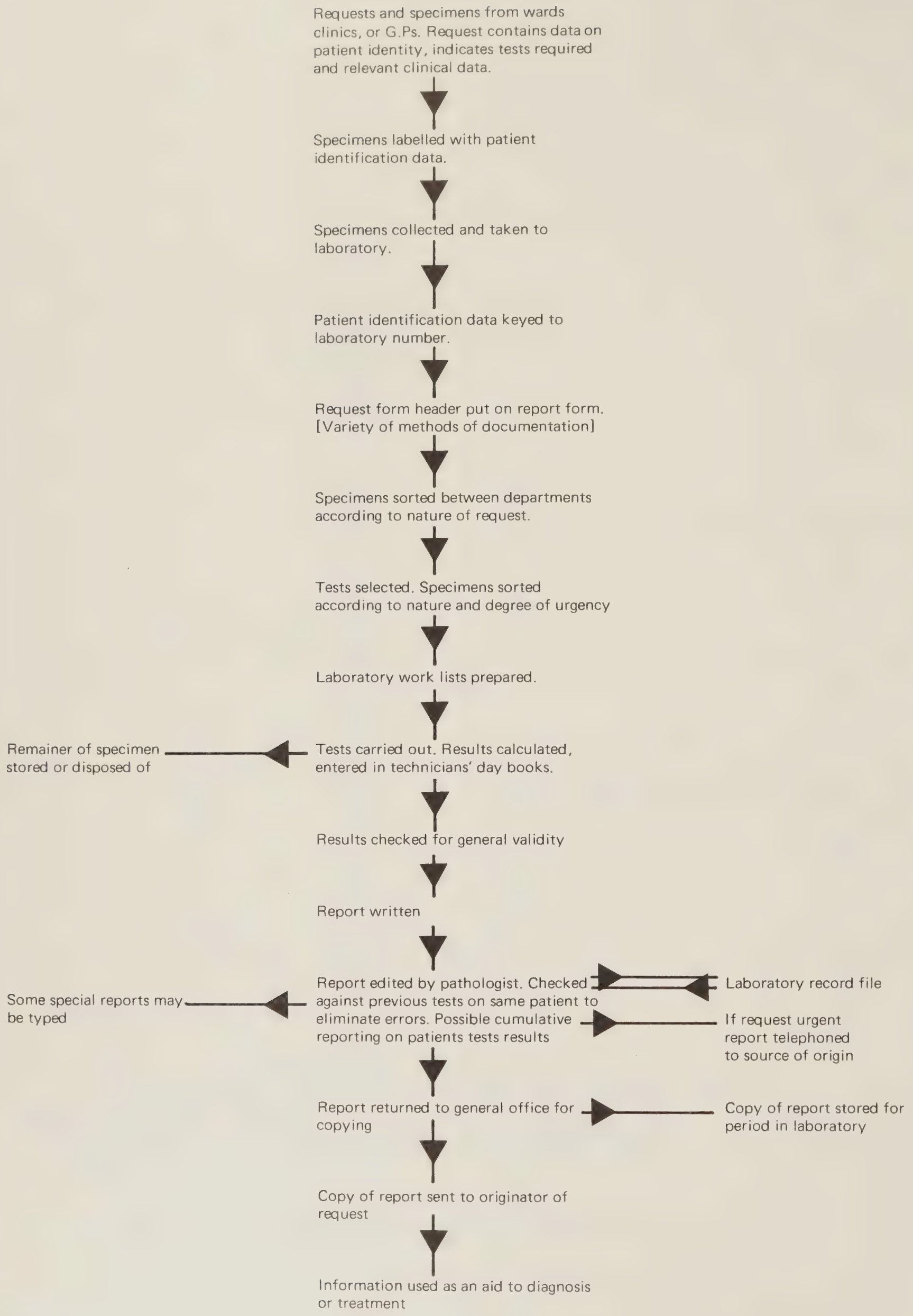

Requests and specimens from wards clinics, or G.Ps. Request contains data on patient identity, indicates tests required and relevant clinical data.
Specimens labelled with patient identification data.
Specimens collected and taken to laboratory.
Patient identification data keyed to laboratory number.
Request form header put on report form. [Variety of methods of documentation]
Specimens sorted between departments according to nature of request.
Tests selected. Specimens sorted according to nature and degree of urgency
Laboratory work lists prepared.
Remainer of specimen stored or disposed of
Tests carried out. Results calculated, entered in technicians' day books.
Results checked for general validity
Report written
Some special reports may be typed
Report edited by pathologist. Checked against previous tests on same patient to eliminate errors. Possible cumulative reporting on patients tests results
Laboratory record file
If request urgent report telephoned to source of origin
Report returned to general office for copying
Copy of report stored for period in laboratory
Copy of report sent to originator of request
Information used as an aid to diagnosis or treatment

FIGURE 6 Flow of requests, specimens and reports through the laboratory (manual data processing procedures)

Specimen taking, specimen handling and records

26. The following functions are common to all pathology laboratories:

(a) Patient examination

With the increasing trend to out-patient investigation at least three consulting/examination rooms are required adjacent to the laboratory waiting area, any of which should be capable of being used for venepuncture which must not be undertaken in the laboratory working area. [14] The greatest patient call is made upon the haematology and chemical pathology departments and consideration should be given to the siting and design of the respective consultants' office/laboratories to enable them to be used for patient consultation at peak times. Branch pathology rooms should not normally be provided in out-patient departments as they tend to be uneconomic in staff time and to duplicate equipment. Hand washing facilities must be available in all areas where specimens are likely to be handled. [8(a)] Coat hooks for protective clothing must be provided as protective clothing worn in these areas must not be taken into offices, rest rooms, recreation rooms, canteens, libraries and other parts of the premises including wards [7(b)]. Disposal of these garments is similar to the disposal of protective clothing described in paragraph 57(c).

(b) Patient reception, general office, administration and records

These functions are administered most effectively when carried out in a combined area. Reports received from laboratory areas will be copied in the general office. The general office will normally maintain an area records section. There should be room for 2 receptionists at peak periods. Current reports may be kept at departmental level for up to one year and older records are usually kept at area level. Histology records are kept for an unlimited period and accommodation for these has to be included in the morbid anatomy department. The pattern of handling and storing reports may change with the introduction of automatic data processing systems.

(c) Specimen reception area

A separate area must be provided for the receipt of specimens. This may be a separate room or a separately identifiable part of the laboratory working area but not part of a clerical office or of a public corridor or part of a patient reception counter. Specimens must be delivered across a fixed bench or table or through a hatch either of which should have smooth impervious surfaces resistant to disinfectants. The area must not be carpeted. Hand-washing facilities and accommodation for protective clothing must be provided. Specimens will be transferred to the appropriate laboratory working area in suitable containers. All specimen containers must be kept upright and where possisble placed in racks. Sufficient racks must be provided to accommodate all specimens. These racks must be capable of being sterilized repeatedly or capable of withstanding prolonged exposure to disinfectants. Disposable racks e.g. of card or expanded polystyrene must be used once only and incinerated after use. [12] Arrangements should be made to deal with any specimen which might arrive in a leaking or otherwise damaged condition—see appendix 7 of the Howie Code of Practice. The provision of a microbiological safety cabinet (Class I) in the specimen reception area to meet such a contingency will be a matter for decision at local level.

III. Design aspects

Determination of content

27. To determine the space requirements for a specific project a brief statement of ''outline project policy'', as indicated in CAPRICODE Hospital Building Procedure Note No. 2: Planning Policies should be made including a list of proposed functions. These functions comprise activities performed by professional or technical staff and they generate what is termed in this Note primary space.

Primary space

28. Primary space is defined as that space which is occupied by professional or technical staff and, for the purpose of assessing the amount of accommodation needed, is expressed in numbers of laboratory space units.

Laboratory space unit

29. The laboratory space unit (L.S.U.) is the basic unit of planning and is a module of laboratory space which may be open bay or enclosed room. It can house a small group of technicians or arrangements of equipment, be sub-divided in a variety of ways or be used as part of an open laboratory space. The dimensions of the L.S.U. are described more fully in paragraph 69 but it is intended that the unit should be used flexibly in design. For the purpose of this Note it is assumed that the most suitable arrangement could be parallel benches running the length of a module measuring approximately 6·1 × 3·3m. These dimensions establish an L.S.U. of 20·5m².

Secondary space

30. Secondary space is defined as that space provided for activities which support those performed in primary space. The ratio of secondary to primary space will often vary for each design solution. For example a larger area laboratory will normally require a relatively smaller proportion of secondary space, and a small satellite laboratory, a relatively higher proportion of secondary space. The Stage A costing procedure (Hospital Building Procedure Note No. 6) provides a margin for variations.

Circulation space

31. Circulation space is defined as space provided for movement of goods and personnel between rooms or bays within the laboratory, apart from space used solely for movement between adjoining and interconnecting bays. For the purpose of costing and space efficiency calculations the internal partitions and minor services ducts are included in the circulation area. A typical ratio for circulation in a pathology laboratory is roughly 30 per cent of net area but lower figures are obtainable in layouts where laboratory bays are deep in relation to their width (e.g. 2:1 or greater) and where the layout is simple i.e. single corridor.

Communications

32. The term ''communications'' refers to those spaces and means of access that are common to several hospital departments and which are accounted for under on-costs. They include the following:

(a) Main access routes such as corridors, entrance halls, staircases, lift wells and lifts (including passenger, goods and bed lifts), escalators and other forms of vertical moving access. Space and equipment required for exclusive vertical access between departments of a laboratory planned on more than one floor is, however, included under ''Circulation.''

(b) Plant rooms and other engineering spaces such as large vertical structural services shafts. These plant spaces are described in paragraphs 92, 97, 166 to 168 and 170 but switchgear rooms and sterilizer plant space (for central wash up) are included under basic (secondary space) accommodation in Table 1.

Auxiliary buildings

33. Under this sub-head is included any accommodation which on account of its special nature has to be provided as a separate building—see Appendix 12 of CAPRICODE Hospital Building Procedure Note No. 6: Cost Control.

Calculation of space requirements

Area laboratory

34. The total space required for each area laboratory will vary in accordance with the level of service it is intended to provide for its own locality: the way in which the total space allocation is sub-divided will similarly be determined by local factors. For example the requirements for office/laboratory accommodation will need to be determined having regard to assessed medical staff needs for the whole laboratory: the recommendations in this respect can therefore be interpreted flexibly between departments within the overall primary space allocation. For guidance and costing purposes however, it is necessary to formulate outline schedules of accommodation and Table 1, therefore, lists what are considered to be appropriate provisions for a typical area laboratory serving a population of approximately 200,000.

Area laboratory with P.H.L.S. component

35. Paragraph 13 refers to the policy of integrating P.H.L.S. laboratories with major hospital laboratories. Within the concept of area laboratories serving populations of 200,000 it is estimated that one in five such laboratories in England and Wales will include a P.H.L.S. component. Thus a P.H.L.S. laboratory in this context could be expected to serve a population of 1,000,000 and a suggested schedule of accommodation for such a laboratory is set out in Table 2.

TABLE 1
Area laboratory (excluding P.H.L.S.) serving population of 200,000

Department	*Sub-department*		*Area in m²*	
			Sub-totals	*Totals*
A. ***Primary space***		LSU		
Morbid Anatomy	Histopathology	4·5		
	Cytology	2		
	Office/Laboratories	2·5	184·0	
Haematology	General Haematology	5		
	Mechanised Section	1		
	Blood Transfusion	2·5		
	Office/Laboratories	2	214·5	
Chemical Pathology	General Biochemistry	5		
	Mechanised Section	3		
	Office/Laboratories	2·5	214·5	
Microbiology	Clinical Microbiology	5·5		
	Virology	1		
	Office/Laboratories	1·5		
	Category B1 Room	1	184·0	
		39		797

TABLE 1 — *continued*

B. ***Secondary space***			
Patient areas	Entrance and waiting	46·5	
	Consulting/Examination rooms (including Bleeding and Venepuncture)	30·5	
	Patients' lavatories (2 × 4·75)	9·5	
Office and Staff Rooms	Reception, General Office, Records	102·0	
	Staff changing, Lavatories and Staff rooms	130·0	
Supply and Processing areas	Stores (including flammable goods)	83·0	
	Chemical Preparation bay	19·0	
	Outfit Preparation	10·0	
	Central Wash-up	82·0	
Special rooms	Morbid Anatomy Slide and Block store	19·0	
	Hot room	10·0	
	Cold rooms (2 × 10·25)	20·5	
	Blood Bank	5·5	
	Fluorescent Microscopy	5·5	
	Workshop	9·5	
	Cleaners' rooms (2 × 4·75)	9·5	
	Disposal room	7·5	
	Switchrooms (2×3·75)	7·5	
			607
C. ***Circulation***	(Approx 30% of A + B)		

This table contains at B a suggested breakdown of areas for those activities carried on in secondary space. However, detailed allocation of secondary space will need to be determined by local consultation in order to achieve the correct balance for each individual laboratory.

Reference laboratories

36. Paragraph 12 indicates the need to provide at certain hospitals additional facilities for some of the less common techniques of pathology, and the specialities which that paragraph described are listed in Table 3 with appropriate areas set out against each of them. It should be re-emphasised that this list is not comprehensive.

TABLE 2

Area laboratory serving population of 200,000 with P.H.L.S. component serving population of 1,000,000

Department	*Sub-department*		*Area in m²*	
			Sub-totals	*Totals*
A. ***Primary space***		LSU		
As in Table 1	As in Table 1	39	797	
P.H.L.S. Microbiology	Milk, water and food laboratories	3		
	Virology (additional to 1 L.S.U. in Clinical Microbiology)	2		
	Office/Laboratories	1·5		
		45·5	133	
				930
B. ***Secondary space***				
As in Table 1	As in Table 1		607	
P.H.L.S. Secondary space	Reception, General Office, Records		23·5	
	Staff Changing, Lavatories and Staff room		18·5	
	Stores		28·0	
	Outfit Preparation		4·5	
	Central Wash-up		18·5	
	Hot room		4·5	
	Cold room		4·5	
				709
C. ***Circulation***	(Approx. 30% of A + B)			

The above Table allocates at B secondary space in approximately the same ratio as in Table 1 but increased areas will be needed for certain spaces already scheduled in Table 1 for a typical area laboratory. Enlarged rather than duplicated spaces are envisaged, the only exception being a separate wash-up which might be required *en suite* with the virology sub-department.

TABLE 3

Reference laboratory serving population of 500,000 and 1,000,000

Sub-department	*Population served*			
	500,000		1,000,000	
	L.S.U.	*Area in m²*	*L.S.U.*	*Area in m²*
A. ***Primary space***				
Cytology (additional to basic)	1	20·5	2	41·0
Trace elements	0·5	10·0	1	20·5
Toxicology	0·5	10·0	1	20·5
Immunology	1·5	30·5	3	61·5
Chromosomes (Genetics)	—	—	1	20·5
Automation	2	41·0	4	82·0
Neuropathology	2	41·0	3	61·5
B. ***Secondary space***	An area of approx. 2/3 of whatever total area is derived from the need for one or more of the above sub-departments should be sufficient for the new secondary space needs.			
C. ***Circulation***	(Approx 30% of A + B)			

Additional accommodation

37. Paragraph 16 recommends the policy of sharing between various hospital departments those elements of general accommodation common to all of them. Where this is not possible the pathology laboratory may require one or more of the additional spaces listed in Table 4.

TABLE 4

Additional accommodation

Space	*Area in m²*
Lecture room/library/museum	74·5
Practical training	20·5
Research	20·5
Darkroom	9·5
Staff duty room	10·0

The provision of any of the above areas would attract an approximate 30 per cent allowance for circulation space as in the previous tables.

Description of accommodation

38. *(a)* The recommendations in paragraphs 39 to 59 which follow relate to the typical area laboratory scheduled in Table 1. Recommendations for the allocation of primary space are expressed in terms of laboratory space units (L.S.U.'s) which should *not* be interpreted as individual rooms, but as representing the amount of space necessary for the various laboratory functions as described. It can be expected that in practice some variation of functional requirements will occur due to centralisation of some non-urgent functions, patterns of existing services or geographical factors.

(b) Each working or specimen reception area must contain at least one hand washbasin to be used solely for hand-washing. If 10 or more persons work in the area, or if there is more than one exit door to a non-working area, then a minimum of two hand-wasbasins must be provided. Basins must be provided near the exit door(s) and they must be of the type without an overflow. The taps should be of the pillar type with spray-head and must be elbow, wrist or foot-operated (on no account should they be hand operated). A paper towel dispenser and foot-operated, free standing sack holder are required. [8]

(c) As protective clothing must not be worn outside the work areas, pegs on which it can be hung must be provided in work areas as near as possible to the hand-washing facilities and exits. They must be positioned to ensure that laboratory workers will not come into contact with the clothing on entering or leaving the work area. [7(b), 10]

Morbid anatomy department

Histopathology sub-department (4.5 L.S.U.'s)

39. *(a) Specimen cutting and processing*

Space is required for dissection of specimens (a bench with adjacent sink and slop-hopper), note taking, automatic processing of specimens in machines, block making, moulding and trimming, and preparation of museum specimens. The specimen cutting area should be partitioned off and mechanically ventilated because of the nuisance from formalin vapour.

(b) Formalin store

Storage racks are needed for holding the tissue specimens. The bulk of tissue specimens are stored in formalin in plastic containers but certain items may require glass jars. The formalin store is subject to formalin vapour nuisance (as in the specimen cutting area) and should therefore be partitioned off from other working areas and be mechanically ventilated.

(c) Section cutting and staining

Space is needed for up to four cutting positions with microtomes, waterbaths and hotplates. The staining area is usually divided into special and routine stains.

(d) Frozen sections and special techniques

Space is needed for the cryostat or freezing microtome in which urgent specimens from the operating theatre may be frozen and sections cut.

(e) Office work

A small office is needed in which the chief technician will write up notes and reports and do some laboratory bench work.

Cytology sub-department (2 L.S.U.'s)

40. *(a) Reception and staining*

Space is needed for the reception/recording of specimens and the preparation and staining of slides.

(b) Microscopy

Space is needed for a number of microscope positions at which the slides are examined.

Office/laboratories

41. Office/laboratories will be used for writing reports, notes etc. and laboratory bench work. In the morbid anatomy department adequate office/laboratory accommodation should be provided for medical staff allowing for a possibility of up to 3 doctors working at any one time.

Haematology department

General haematology sub-department (5 L.S.U.'s)

42. Space is needed for the reception, recording and preparation of specimens.

(a) Special and general tests

Several special tests will be carried out. Space is also needed for routine haemoglobin estimations and particle counting. Slides of specimens will be made and then stained and examined under a microscope.

(b) Microbiological assays

Requests are usually batched and tests performed on two or three days per week. An undisturbed environment (i.e. a traffic free, partitioned area) is required in order to achieve accurate results.

(c) Coagulation

Tests are carried out on a bench using sub-samples to check abnormal conditions against the normal.

(d) Electrophoresis

Space is needed for special tests.

(e) Office work

A small office is needed in which the chief technician will write up notes and reports and undertake some laboratory bench work.

Mechanised section (1 L.S.U.)

43. An area should be allocated for mechanised techniques and this section can usefully be related to the chemical pathology mechanised section. A close relationship with routine haematology is essential as some of the workload is interchangeable.

Blood transfusion sub-department (2.5 L.S.U.'s)

44. A separate sub-department should be provided for blood transfusion activities which will include blood grouping, cross matching and serology tests. This sub-department should be partioned off from the main laboratory area in order to avoid disturbance to the work and the consequent risk of errors. Space should be allocated for a refrigerated centrifuge and a horizontal laminar flow cabinet (outflow) for the preparation of packed red cells.

Office/laboratories (2 L.S.U.'s)

45. In the haematology department adequate accommodation should be provided for medical and scientific staff allowing for a possibility of up to 3 working at any one time.

Chemical pathology department

General biochemistry sub-department (5 L.S.U.'s)

46. *(a) Reception, recording and preparation of specimens.*

Space is needed for automatic shakers and centrifuges. Certain of the latter are known to operate at an excessively high noise level and it may be necessary to provide soundproof accommodation for the centrifuges if a noisy type of machine is to be used.

(b) Special and general tests

Traditionally biochemistry has a higher demand for bench space and services than in other departments as more apparatus is used and a wider range of tests undertaken. This need is recognised in the provisions of 3 L.S.U.'s in the mechanised section. Faeces and urine may contain category B1, B2, or other pathogenes and the precautions set out in paragraph 25(*a*) and *(b)* of the Howie Code of Practice must be observed. A microbiological safety cabinet (Class I) must be provided for the operation of homogenisers [25(a)(ix)], and a sluice must be provided for the disposal of urine samples. [25(a)(xi)] A fume hood and a fume cupboard are required for chromatography work, one to house tanks and one for spraying. It is not essential that a separate room should be provided for this function. A separate balance room is not considered necessary; if air damped balances are used they should be located in traffic free areas and isolated support benching used. A fume extract will be needed for the flame photometer.

(c) Trace elements and toxicology

All but urgent (e.g. barbiturates) requests will probably be referred to sub-regional reference units. Where possible fume cupboard requirements can be met by grouping the cupboards and sharing their use.

(d) Steroids

Steroid work should, whenever possible, be undertaken on a sub-regional basis. Where this work is undertaken a special room is required as smelly and inflammable solvents are used.

(e) Office work

A small office is needed in which the chief technician will write up notes and reports and undertake some laboratory bench work.

Mechanised section (3 L.S.U.'s)

47. An allowance of 3 L.S.U.'s should be made for the progressive expansion of mechanised biochemical techniques. The area can usefully be related to the

haematology mechanised section. The mechanised equipment can be housed on adjustable shelves or worktops rather than on conventional benches. New apparatus serving the same function will probably be free standing. Ample electrical outlets should be provided; there should also be water and drainage points and account should be taken of the need for continuous flushing of corrosive effluents.

Office/laboratories (2.5 L.S.U.'s)

48. In the chemical pathology department adequate accommodation should be provided for medical and scientific staff allowing for a possibility of up to three working at any one time.

Microbiology department

Clinical microbiology (6.5 L.S.U.'s)

49. Daylight, preferably northlight, can be of advantage for examining plates and if appropriate this should be taken into account where possible in planning the department, see paragraph 70*(c)*.

(a) General bacteriology

Up to one half of the length of the service spine can be expected to be used for supplying free standing equipment. Space is required for bench work and microscopy with facilities for centrifuges, microscopes, waterbaths and local adjustable lighting where cultures are examined.

(b) Media preparation and plate pouring

Space is required for the storage and preparation of bulk media and the pouring of plates. The plate pouring should be done on a level bench in draught-free conditions. The media preparation room should be close to the central wash-up and sterilizing room in order to share the sterilizing facility.

(c) Serology

Space is required for waterbaths, incubators, a table centrifuge and a mechanical shaker in addition to space for bench work and report writing.

(d) Separate accommodation for the handling of Category B1 pathogens

All laboratory activities involving Category B1 organisms, agents and materials as defined in paragraphs 2*(b)* and 11 of the Howie Code of Practice must be transacted in a separate room. One L.S.U., or minimally 18m^2, would be adequate for this purpose in all but the larger laboratories and specialised units, such as regional centres for tuberculosis bacteriology, and regional virus laboratories where much work with hepatitis viruses is carried out. This room must contain microbiological safety cabinets (Class 1) as specified in paragraph 24 of the Code of Practice (see paragraph 20*(b)* and the list of definitions in this building note). Hand-washing facilities with paper towel dispenser, a foot-operated free standing sack holder, a refrigerator, and in virology/serology laboratories a separate chest type deep freezer, must be provided. Any door giving access to or exit from a Category B1 room must be fitted with a lock so that the room may be locked when unoccupied. The door(s) should have a glass observation panel and must be of the ½ hour fire resistance type. All doors giving access to the room must clearly display on the outside a warning notice 'DANGER OF INFECTION' within the international 'Biohazard' symbol (see paragraph 20*(f)*). As it may be necessary to fumigate such rooms, e.g. with formaldehyde, duct-work and services should be planned to prevent leakage to other rooms. The ventilation system should be designed to produce a negative pressure within the room and there should be 6-10 air changes per hour. The ventilation system must be so balanced that these conditions are not disturbed by switching on or off of the microbiological safety cabinet (Class 1) which is an essential feature of these rooms. To prevent the transfer of infectious air-borne particles to another part of the building, total-loss ventilation is necessary in Category B1 rooms. The extract from the safety cabinet, when running, may be used to provide ventilation and control of air movement. Make up air should enter the B1 room via a transfer grille in an internal wall/partition. Alternative ventilation should be provided when the safety cabinet is not in use and in the case of a simple building this may be by means of an extract fan, discharging to outside with the motor electrically interlocked with that of the safety cabinet to ensure that only one or the other operates.
Any area already in existence for the handling of tubercular specimens can be adapted by incorporating the provisions indicated above to provide a room for the handling of Category B1 pathogens. It is likely that existing rooms designated as B1 accommodation are naturally ventilated by means of opening windows. Safety cabinets should not operate with adjacent windows open because draught can seriously impair their performance. It is desirable therefore to provide some form of external solar control, blind or canopy, where necessary so that safety cabinets can be used with closed windows. A small 'through-the-wall' air cooler unit could be considered if the workload is likely to necessitate working with closed windows for lengthy periods, but care should be taken in siting, selection of air volume and discharge velocity so as not to affect performance of the safety cabinet.

(e) Office work

A small office is needed in which the chief technician will write up notes and reports and undertake some laboratory bench work.

Virology (1 L.S.U.)

50. Space is required to carry out the simpler virology tests, using bought-in culture material.

Office/laboratories (1.5 L.S.U.'s)

51. Adequate accommodation should be provided for medical and scientific staff allowing for two working at any one time.

P.H.L.S. microbiology department

52. Where P.H.L.S. microbiology is fully integrated with clinical microbiology in a joint laboratory an additional 6.5 L.S.U.'s should be allocated in addition to those allocated

for clinical microbiology. A suitable distribution of L.S.U.'s follows.

P.H.L.S. microbiology (3 L.S.U.'s)

53. As in clinical microbiology, daylight (preferably northlight) can be of advantage for examining plates and this should be taken into account where possible when planning the department.

(a) Milk, water and food laboratory

Tests are carried out to check the purity of milk, water and foodstuffs. Owing to the potential smell nuisance, adequate provision of fume hoods and extract ventilation is required. Access to a microbiological safety cabinet (Class 1) will be necessary.

(b) General laboratory

This should be designed integrally with the clinical general laboratory. The P.H.L.S. element is concerened mainly with epidemic and hygiene control. Integration of the clinical and P.H.L.S. laboratory will ease the problem of load fluctuation in epidemic situations. All the general laboratory spaces need good access to the hot and cold rooms.

(c) Office work

An office is needed for one chief technician who will cover both clinical and P.H.L.S. microbiology.

P.H.L.S. virology (2 L.S.U.'s)

54. Space is needed for culture preparation, inoculation and culture, and serology. This accommodation will be integrated in a joint laboratory with the 1 L.S.U. allocated for virology under clinical microbiology, making a total of 3 L.S.U.'s.

Office/laboratories (1.5 L.S.U.'s)

55. With the 1.5 L.S.U.'s allocated in clinical microbiology the total provision will be 3 L.S.U.'s in an integrated department. The additional office/laboratories will be needed for the P.H.L.S. director, deputy director and possibly a further doctor. The director's room may also be used for periodic conferences on public health and epidemic control. Conferences may alternatively be held in any other suitable room such as the library, if one exists.

Patient areas

56. *(a) Entrance and waiting area*

The entrance and patient waiting area can be combined. Accommodation is required for up to 20 patients as, in general, appointment systems are found to be inconvenient both to patients and staff.

(b) Patient examination rooms

The accommodation described in paragraph 26*(a)* should be planned and equipped for flexibility of use.

(c) Patient lavatories

One male and one female lavatory should be provided adjacent to the patient examination room for patients' use and specimen collection.

Offices and staff rooms

57. *(a) Reception, general office, records and senior chief technician*

This space may be used as one large central unit, or a combination of central unit with secretaries at departmental level. Whatever arrangement is adopted it should be designed flexibly to take into account future installation of computerised record systems involving either a small peripheral on-line computer or direct links to a central processor. Any office accommodation required for a senior chief technician can be included in this space.

(b) Staff changing

Staff working in the laboratory environment must be provided with their own locker accommodation for holding outdoor clothing, handbags etc. The accommodation should be provided close to the laboratory complex but not within any laboratory working area. [10(a)]

(c) Protective clothing

Storage accommodation for a sufficient supply of protective clothing of various kinds must be provided for those working in the laboratory (including maintenance workers) and any visitors. Pegs will be required in working areas, offices and patient areas, preferably situated beside the hand-basin, for protective clothing to be hung when staff leave a working area—see paragraph 38*(b)*. Suitable containers must be provided for discarded protective clothing. Any clothing used in Category B1 conditions must be sterilized by autoclaving before it is sent to the laundry. [7(b)]

(d) Staff lavatories

The number of W.C. fitments, urinals and lavatory basins should be related to the number of male and female staff. (For guidance see British Standard Code of Practice CP3: Chapter VII (1950) Table 7.)

(e) Staff rest room

A staff rest room must be provided as staff are not permitted to smoke, eat or drink in laboratory areas. This room must, therefore, be situated separately from the laboratory working area but within or convenient to the laboratory building: protective clothing must not be worn in this room. It must be of sufficient size to accommodate the maximum number of staff likely to be present at any one time. It should contain a refrigerator used solely for culinary requirements, a means of preparing light snacks and facilities for tea making, washing up and storage. Good ventilation to remove smoke and cooking smells should be provided. [9]

Supply and processing areas

58. *(a) Stores*

The location of designated storage areas within the laboratory will depend on the layout of the laboratory and its particular operational policies. Additional storage space will be available in under-bench fitments. Overbench storage units will be restricted mainly to 'in use' reagent bottles in the open plan concept. An outdoor flammable goods store, where the major proportion of highly flammable liquids should be stored, should be provided in the open air adjacent to the laboratory. It may usefully be grouped with other flammable goods stores (e.g. works department) in order to share vehicle access etc. (See

Hospital Building Note No. 34: Works Department, paragraph 46).

(b) Chemical preparation bay

An area separate from the laboratory work stations in chemical pathology will be required for the bulk storage, making up and dispensing of reagents etc. Provision of a centralised facility such as this will release useful bench and storage space at several work stations which would otherwise have to accommodate balances of various types and other equipment that would have (at these work stations) only intermittent use.

(c) Outfit preparation

Specimen containers are issued by the laboratory to all those who require to send in specimens. Space is needed to assemble, label and store containers and forms. The space should be near the reception area.

(d) Central wash-up and sterilizing

Central wash-up facilities serving all departments provide the most economic service from both capital and revenue aspects. The central wash-up and sterilizing rooms should be located near their major user, the microbiology department, in order to minimise staff movement and reduce the possible dangers arising from the transport of discarded cultures for sterilization. The media preparation sterilizers can also be housed in the sterilizing room if the media room is sited nearby. Items are generally placed in baskets or trays for handling in the wash-up and sterilizing area. A slop-hopper is required for the disposal of solid or liquid waste. Items are first passed through a sterilizer to sterilize bacterial cultures before being passed through washing machines or sinks. Two manual washing stations are required and two automatic washing machines. Each manual washing station may require two to four sink units with hot and cold water and distilled or deionised water. After washing, items are passed through a drying cabinet, sterilized as required and then labelled. Finally they are returned to the departmental areas. Space is required to stack both empty and temporarily held (full) baskets. It is essential to have one autoclave designated to sterilize both material to be discarded and contaminated material before it is washed or removed to the disposal room to await incineration. The autoclave for discarded or contaminated material must be located at the dirty side of the sterilizer room and the autoclaves and hot air ovens for media and washed apparatus must be located at the clean side. Careful consideration must be given to the ventilation of the areas in which sterilizers are located and provision must be made for proper access to them for maintenance. (See Health Technical Memorandum No. 10: 'Sterilizers'.) The biochemistry sub-department may require a small departmental wash-up area for pipettes and special glassware. The departmental space allocation allows for this. Where the area laboratory is integrated with a P.H.L.S. laboratory allowance should be made for virology wash-up either *en suite* with the virology sub-department or centrally in the main wash-up area.

Special rooms

59. *(a) Hot room*

A hot room is required for incubating cultures and it should be near its prime user the microbiology department. The room should be kept at 37°C and should be large enough to allow a technician to work in it at a work bench.

(b) Cold room

Cold rooms are needed by the chemical pathology, haematology and microbiology departments for storing specimens and media. Two compartments are required, one kept at 4°C and the other (leading off it) at minus 20°C; but see paragraph 140 for a possible alternative arrangement. The first compartment could usefully be entered via an air lock and should be large enough to accommodate a small working area where certain tissue preparations can be carried out. When a laboratory is planned in two sections, either on two floors or on opposite sides of a court, duplicated cold room facilities will normally be necessary in order to relate them closely to their users.

(c) Blood bank

The blood bank should be near the blood transfusion sub-department. Blood is usually obtained at regular intervals from the Regional Blood Transfusion Service, kept in bottles and either used or returned. Space may be required for three refrigerators, i.e. the first as the blood bank, the second for compatibility-tested blood and the third as a night bank. They should be sited so that normal access to them can be effectively controlled, while allowing easy access at night.

(d) Fluorescent microscopy

A small darkened room is needed for special microscope work. This room will be shared by the departments in the laboratory.

(e) Workshop

A room is required where immediate repairs can be made to equipment and where perspex cutting for museum specimen containers can be carried out. Extract ventilation should be provided on account of the use of flammable solvents and the dust caused by perspex cutting. The room should be provided with a work bench to take a vice and socket outlets for electric power tools. The future installation of increasingly complex laboratory equipment may demand more space for its servicing which, unless allowed for in planning the original workshop, may have to be carried out *in situ*. Space for accommodating additional servicing tools, spare parts and modules should in any case be provided.

(f) Cleaners' room

On the basis of one room per 1000m^2 of floor space and depending on layout and operational policy two rooms may be needed in an area laboratory. Each room should have a bucket, sink with hot and cold water, a drainer and enough space for mechanical cleaning equipment and storage of cleaning utensils, etc.

(g) Disposal room

Space must be provided for holding bagged possibly contaminated material awaiting removal to the incinerator: the space should have easy access to disposal routes to facilitate transport of items to the incinerator area and must not be sited where the general public can come into contact with it. [18(b)(ii)]

(h) Switchgear rooms

Pathology laboratories are heavy users of electricity and for ease of maintenance walk-in switchgear rooms, as opposed to cupboards opening on to corridors, are recommended. One room for each 1000m^2 will be required. If the laboratory is to be an independent building, however, one switchroom will be required to act as the intake room in addition to its function as a local distribution centre, and in this case its area should be increased to approximately 16m^2.

(j) Slide and block store

Space is needed for the short term storage of morbid anatomy specimen blocks and slides in a position adjacent to that department. It should be remembered that slide storage cabinets present heavy floor loadings.

Siting

60. The correct siting of the laboratory may provide the hospital planner with his greatest problem. He will be required to resolve the conflict between the need to locate the laboratory in a position accessible to the other hospital departments it serves and the requirement to allow for growth and change. Regional policies and the predicted population rise in individual catchment areas will dictate what actual provision for expansion should be made, but in all cases a potential increase of one third in floor area should be considered as a minimum requirement. This ratio could possibly be reduced with a more intensive use of mechanisation and the other techniques mentioned in paragraph 15.

61. Although this Building Note gives no guidance on the provision of a radioisotope diagnostic service, if such a sub-department is to be included within the pathology laboratory then proper account should be taken at the planning stage of the requirements of the Code of Practice for the Protection of persons against Ionizing Radiations arising from Medical and Dental Use and of the influence which the special characteristics of the service will have on the siting of the laboratory as a whole. The most important of them are as follows:

(a) It may need to be near a point where supplies can be delivered by motor transport so that radiopharmaceuticals in heavy containers do not have to be carried long distances.

(b) It should be sited to minimise through traffic so as to avoid the risk of contamination in the event of accidental spillage.

(c) It should also be near the route of a main sewer for ease of disposal of radioactive waste.

(d) Exhaust air from active areas should be discharged through separate ducting to the outside of the building at a point preferably above roof level.

Layout

Flexibility

62. The boundaries between laboratory departments are becoming less rigid and some techniques are now interdepartmental. For example many routine biochemistry and haematology tests can be carried out by machines in a shared mechanised section, and mechanisation of other laboratory techniques are being developed. The different rates of growth of each department and the continual development in equipment design and techniques demand that the laboratory building should be sufficiently adaptable to accommodate these changes. The structure, services, equipment and finishes should permit the original allocation of space and the layout to be changed during design and while the building is in use with minimum of disturbance. Flexibility for use is needed so that areas can be converted from secondary to primary space or vice versa. This is in the interests of rearrangements resulting from expansion or change of emphasis and in the interests of temporary phasing and decanting. Open planning with a suitable arrangement of bays will allow a compact layout and a high ratio of usable bench length to floor area. A continuous strip of laboratory bays will allow ebb and flow between the different departments in accordance with changes in laboratory technique and organisation.

Long-term flexibility

63. This is related to such matters as future enlargement of the laboratory, major policy changes, addition of computers, etc. and at the primary planning stage should be regarded in whole-hospital terms.

Short-term flexibility

64. This is essential for efficient laboratory operation in circumstances of rapid technological change and may be largely satisfied by the use of movable or adjustable benching systems in association with an installation of service mains that has been designed to permit the repositioning of outlets. This type of approach will avoid the need to provide a large number of spare outlets and fittings in order to satisfy an unpredictable future need, much of which may never arise. For instance, a few large sinks which are capable of being moved without undue inconvenience are both more economical and more convenient than a larger number of small fixed sinks to ensure that one is provided wherever it may be needed. In many cases, however, it will be found that a fixed layout of services and equipment can be designed to be conveniently used in a number of alternative ways providing that working methods can be adapted or modified to fit the layout. Such variations in working methods will often be preferable to the provision for little used flexibility which is not taken advantage of because of the administrative or physical inconvenience of making the alteration involved. A simple basic layout of spaces and equipment which can be supplemented or modified to suit different requirements is likely to be more efficient overall than a layout designed to

suit a particular working method which may have changed or have been superseded by the time the building is complete and in use.

Single storey planning

65. Flexibility of use is more likely to be obtained by planning the laboratory on one level. This arrangement will allow easy movement between the various disciplines and will enable future regrouping of them to be more easily managed. Duplication of functions common to several laboratory departments, such as administration and stores, can be avoided and the provision of vertical links in the form of hoists, lifts and stairs will not be necessary. A laboratory at one level can be planned in a variety of ways and the selected form will be dictated largely by the constraints imposed upon it by the rest of the hospital to which it will be attached. Nevertheless a one-level laboratory will inevitably fall into one of two categories, namely, either single or double corridor.

Multi-storey planning

66. The planning options for the laboratory may often be restricted by the need to integrate it within the comprehensive discipline of its parent hospital, so that sometimes a two-storey (rarely more) solution is unavoidable. In this situation care must be taken to ensure that the more closely related departments are planned at the same level and that the need for vertical access between floors, either by people or goods, is minimised. Thus haematology, chemical pathology and the reception area for patients should be on the same floor and it may be necessary to provide separate office and other common ancillary accommodation at both levels. It is unlikely that a laboratory of the size described in this Building Note which is planned on more than one level will need to be of the double-corridor deep-plan form indicated in Diagram 8. Irrespective of the choice of a single or two storey plan, the accommodation should occupy the top level(s) of any multi-function building of which the laboratories form part. This will greatly assist in the design and the ultimate effectiveness of the special ventilation and extract requirement of laboratories, particularly the system required for safety cabinets and fume cupboards.

Single-corridor layout (Figure 7)

67. This is the simplest arrangement and has the obvious advantages of being able to provide natural light, ventilation and a view to a high proportion of rooms. Open planning can be employed and both primary and secondary spaces may be accommodated within a common module for structure and services.

Double-corridor layout (Figure 8)

68. This arrangement offers a more compact layout with the possibility of a closer relationship between primary and secondary spaces and easier access between laboratory departments. The extra costs of providing additional mechanical ventilation and artificial lighting to the internal zone may be offset to some extent by grouping in that area those spaces requiring a controlled environment together with rooms which are used by people only for short periods. These spaces would include hot and cold rooms, darkroom, stores, changing rooms, lavatories and the mechanised section of the laboratory. Nevertheless it is probable that as discussed in Appendix 2 of CAPRICODE Hospital Building Procedure Note No. 6: Cost Control the increase in engineering costs of a deep plan arrangement are likely to outweigh the reduction in building costs brought about by an improved external wall/floor area ratio.

The laboratory space unit (L.S.U.)

69. The most useful unit of laboratory space is a module which houses a small group of technicians and/or equipment. These modules can either be bays incorporated within an open laboratory space, being subdivided as necessary to provide smaller workspaces, or they can be partitioned off to give privacy, control air movement, or isolate smelly or noisy activities.

(a) Shape of the L.S.U.

Rectangular units are more useful than square ones because area for area they possess a greater perimeter and can therefore accommodate longer runs of benching. Diagram 9 illustrates this principle and it should be noticed that Example A has the added advantage of providing longer runs of straight benching which, as explained in paragraph 70*(b)* are able to be used more flexibly. Even more important, perhaps, a building planned with deep bays will be more compact, more economic in circulation space and will have a lower ratio of external wall to floor area.

(b) Dimensions of the L.S.U.

Paragraph 29 assumes that a useful module for the L.S.U. would be one measuring about 6·1m × 3·3m. These dimensions are determined to a large extent by the limits of human reach, the clearance between benches required by workers at each of them and the general traffic occurring within the module. Diagram 10 illustrates some of the planning variations possible with the use of deep bays.

Fitments

Benches and service spines

70. *(a) Width of benches*

Controls and apparatus can be manipulated most easily on the front 400mm or so of the bench. In practice a bench width of 600mm will accommodate most equipment and will enable technicians to lean over it to adjust it or to manipulate controls. Bulky equipment such as microtomes, tissue processors, etc., may need 700mm wide benches, and mechanised equipment may need wider benching still, or alternatively be freestanding on the floor, requiring service spines only (see *(d) below).*

(b) Length of benches

Bench space may be used either by individual technicians or it may be used for particular processes or test procedures. The length of bench needed for each technician or test procedure will vary between disciplines and serviced bench lengths of 6·1m provide sufficient flexibility to accommodate either 2, 3 or 4 technicians, various test procedures and associated equipment. Future flexibility would be

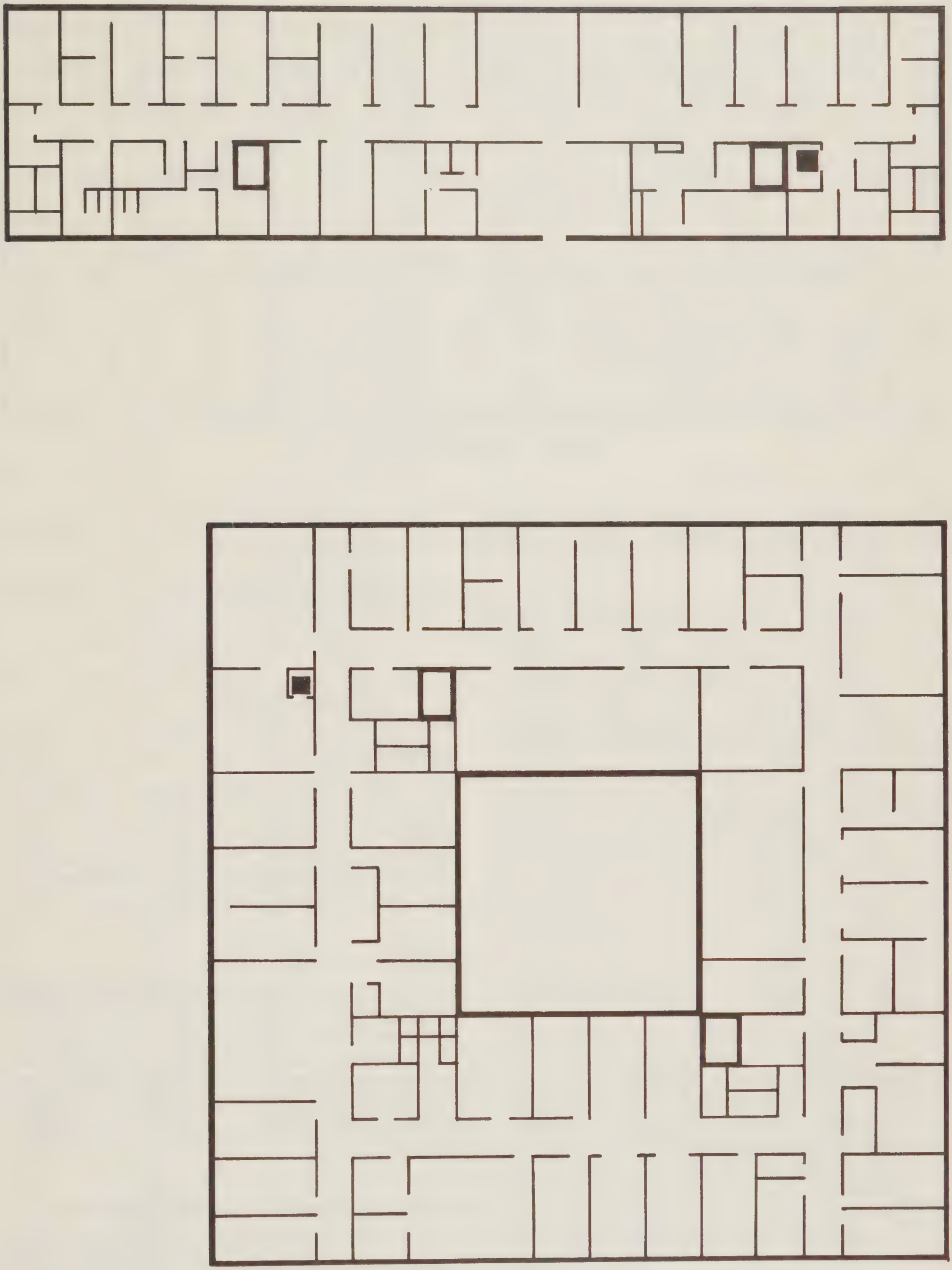


FIGURE 7 Single-corridor layouts

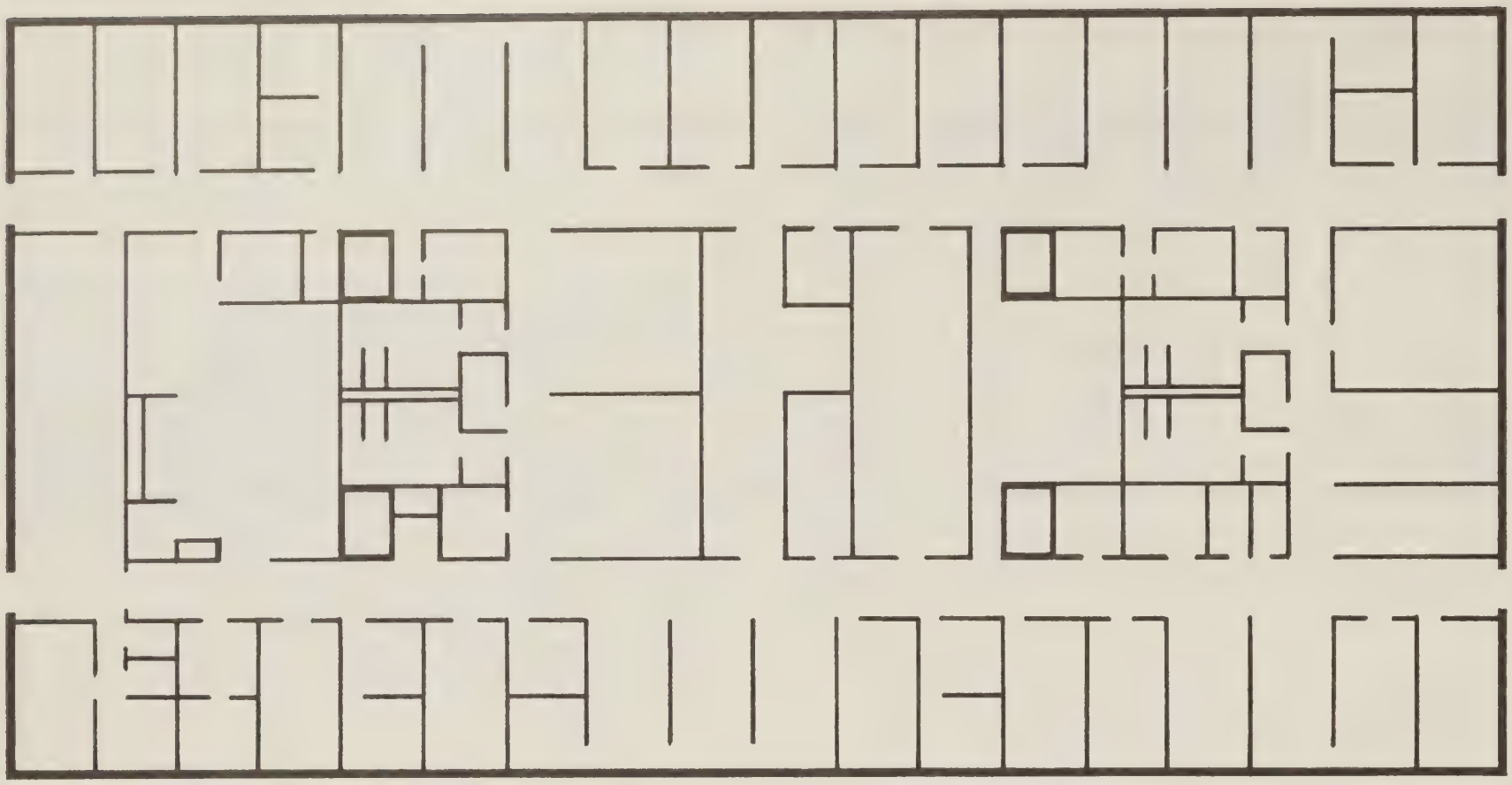


FIGURE 8 Double-corridor layout

obtained by the use of interchangeable modular lengths of benches some of which would incorporate sinks.

(c) Layout of benches

Cost limits dictate that most laboratories will be heated conventionally by perimeter radiators, convectors, etc. and they will also be equipped with windows that are operated manually. These two factors suggest that the best arrangement of benches will normally be parallel rows at right angles to the window wall and this form is shown in Figure 10. There is sometimes a demand for benches adjacent to and parallel with the window in the microbiology sub-department because of the high level of natural light demanded by that discipline. However the required viewing conditions can be reproduced by modern artificial lighting methods and so the preferred bench layout may be maintained in that area also.

(d) Service spines

In order to be able to satisfy the servicing demands of new procedures, as well as to allow for the rearrangement of working positions and underbench storage, the bench services should be run in a spine behind and completely independent of the benches themselves. This arrangement would, for instance, permit whole sections of benching to be removed in order to accommodate floor-mounted apparatus which could then be connected to the plumbing, electrical or other services carried within the freestanding spine. Figure 11 illustrates typical modules of service spines which, as with the benches, could be of various lengths and could be assembled to achieve any total length that might be required.

Storage

71. It should be possible to provide storage in a variety of ways such as the following:

(a) Overbench adjustable shelving or cupboards

(b) Underbench drawers

(c) Underbench cupboards, either floor mounted and supporting the bench top or mobile on castors

(d) Adjustable tracking for wall mounted equipment

(e) Trolley storage, the trolleys being capable of being pushed under the benches.

Partitions between bays

72. Partitions will be needed between some laboratory spaces to give acoustic or visual privacy. Others will be required to isolate smelly or toxic processes and could be glazed above bench level. It would be advantageous if these partitions were capable of being installed or demounted with a minimum of disturbance to services and benching.

Total fitting out system

73. The preceding three paragraphs have emphasised the advantages to be obtained by the use of laboratory components which are able to be re-assembled to meet the changing nature of laboratory functions. Figure 12 illustrates a demountable assembly of service spine units planned in conjuction with storage and worktop units which are available from the Manufacturers' Data Base (Section 5/1: Storage and Worktop Units).

Provision for automatic data processing equipment

74. An area laboratory may have automatic analysing equipment linked to a computer. Some computers require special accommodation and environmental conditions. Further details may be obtained from the Department of Trade and Industry publication "Computer Installations: Accommodation and Fire Precautions" and the appropriate computer manufacturer.

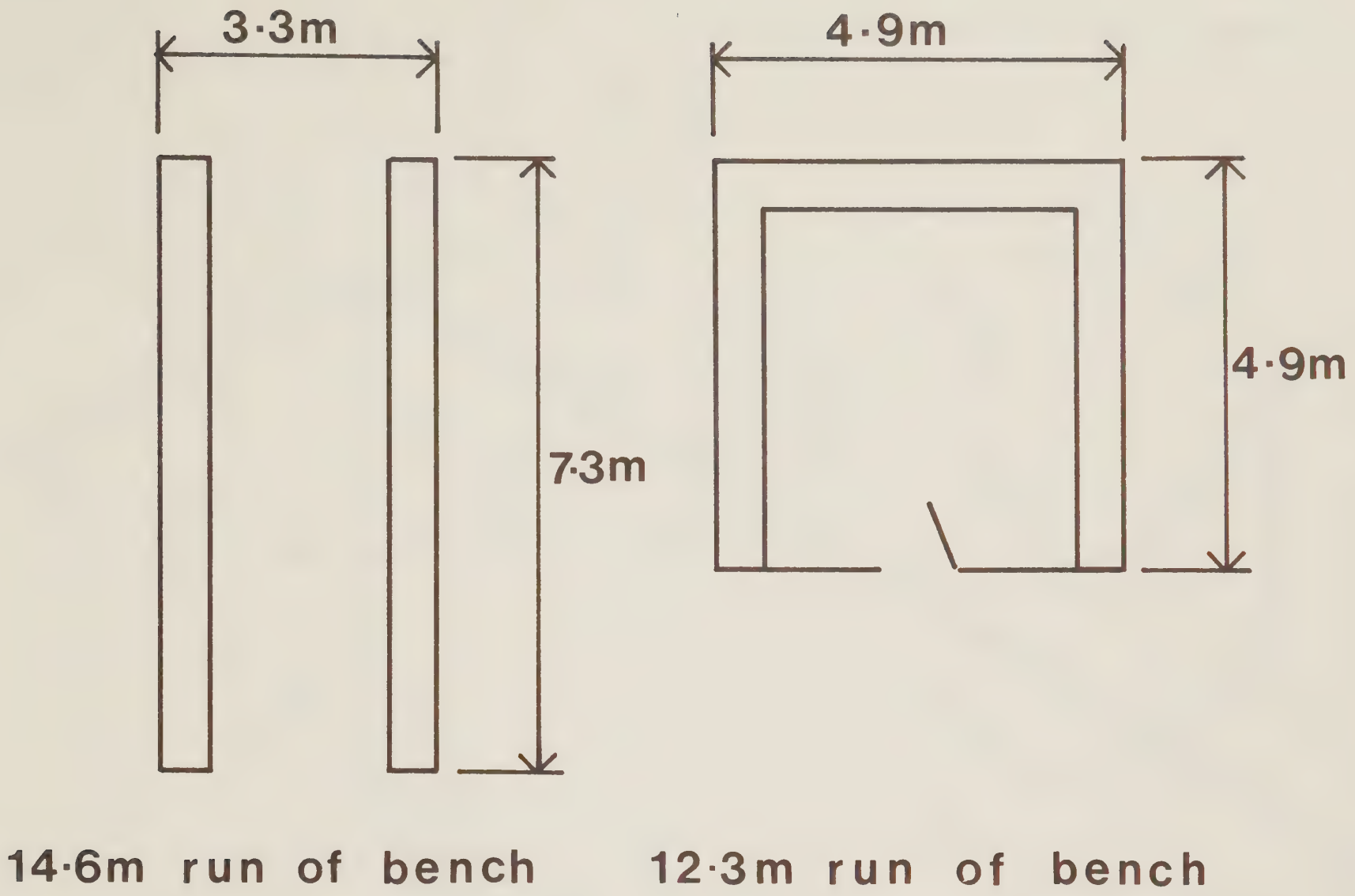


FIGURE 9 Two spaces having an area of approximately $24m^2$

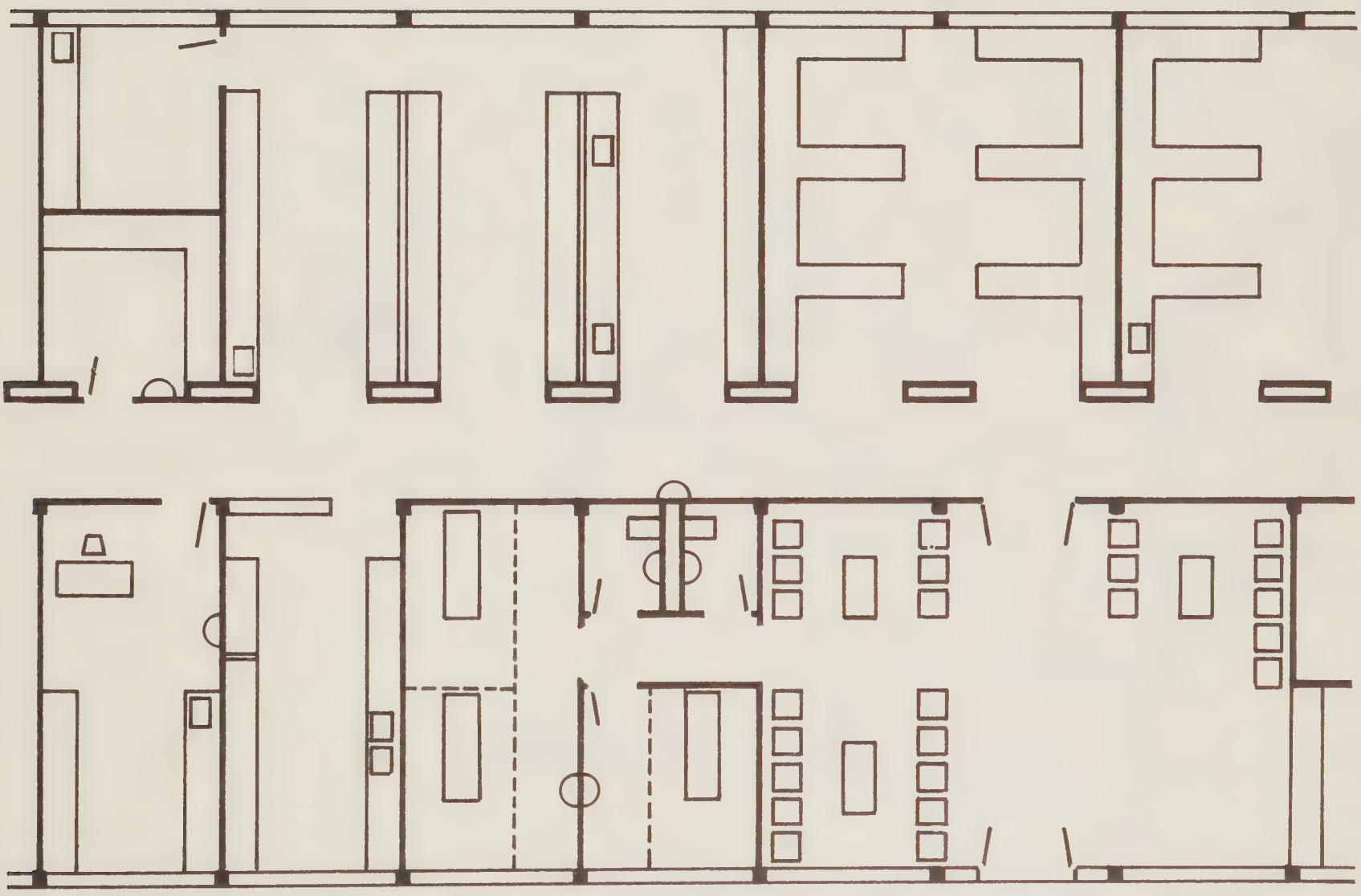
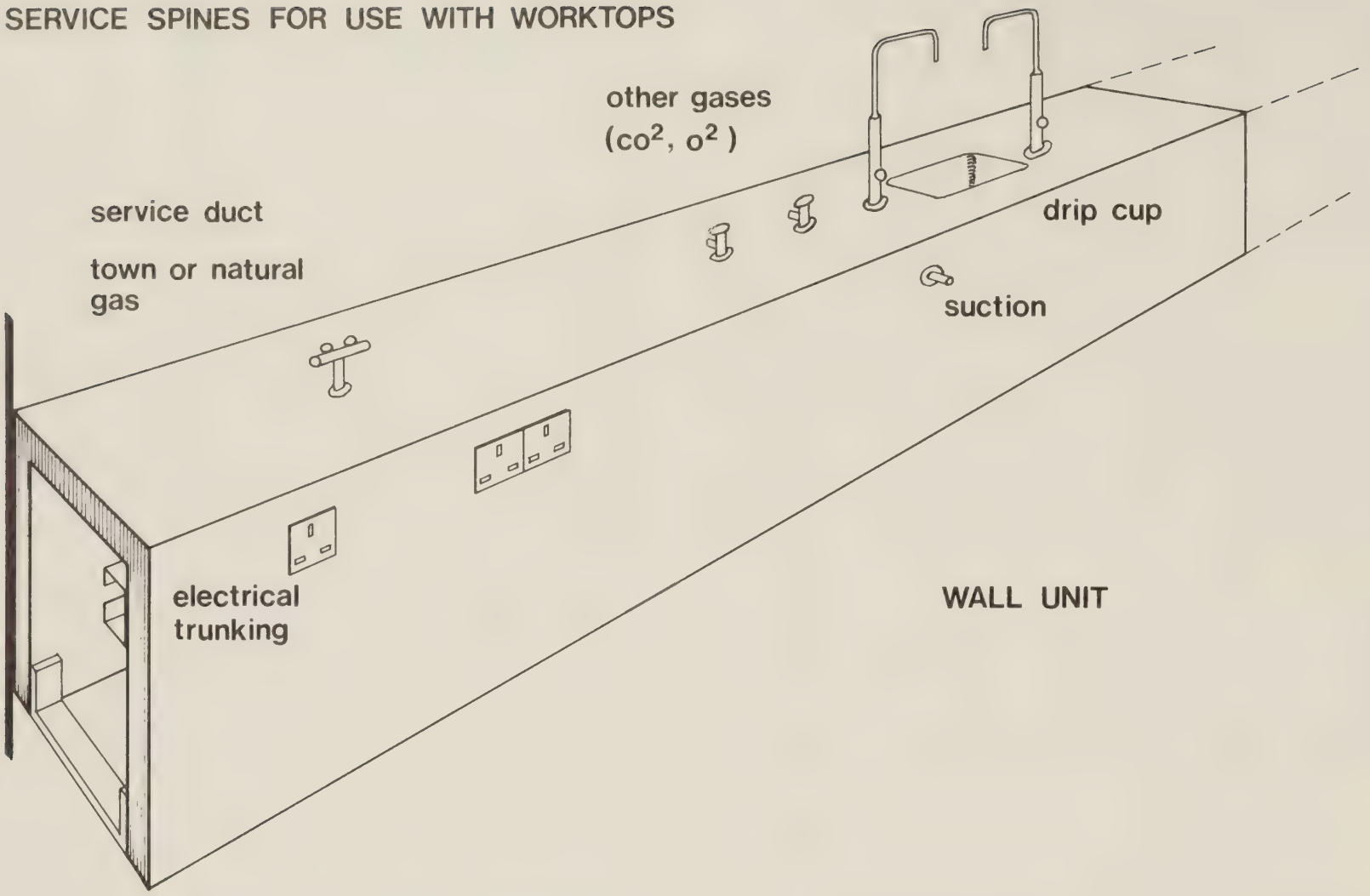


FIGURE 10 The concept of bay planning

SERVICE SPINES FOR USE WITH WORKTOPS



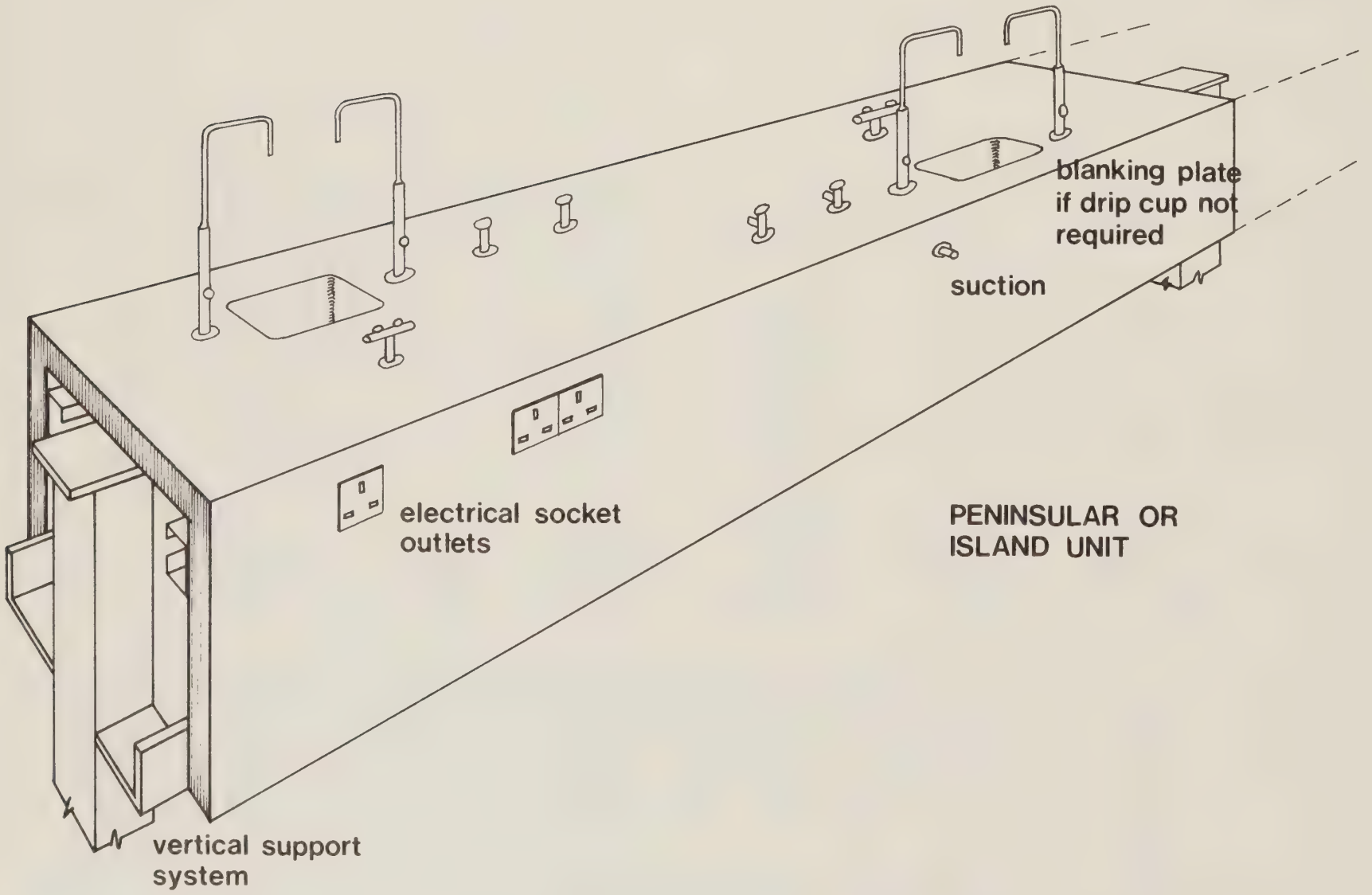


FIGURE 11 Service spine modules

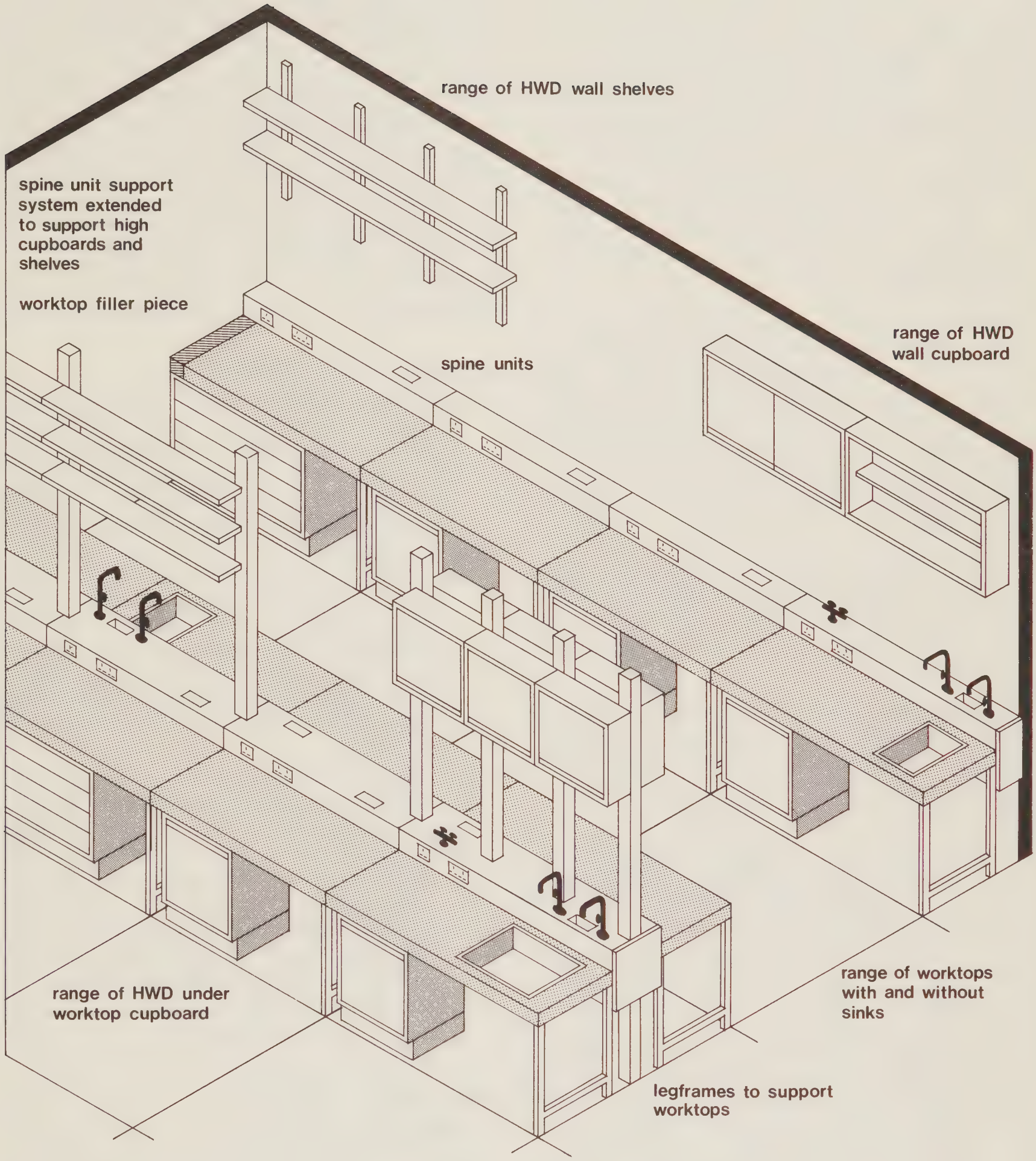

range of HWD wall shelves
spine unit support system extended to support high cupboards and shelves
worktop filler piece
spine units
range of HWD wall cupboard
range of HWD under worktop cupboard
range of worktops with and without sinks
legframes to support worktops

FIGURE 12 Total fitting-out system

IV. Engineering services

General

Preliminary considerations

75. A pathology laboratory requires a greater variety of engineering services than any other hospital department. An ideal installation would be so complex and costly, with conflicting architectural and engineering solutions, that it is essential to evaluate the various alternatives carefully before any major design decisions are made. The following are the most important factors to be considered at the outset:

(a) Whether the laboratory is to be an isolated unit or whether it will be embedded within a multi-departmental complex and required to fit in with the servicing needs and structural system developed for the whole building.

(b) Services must be planned so that maintenance and modifications may be effected with a minimum of disturbance to the laboratory as a whole. In this connection it must be remembered that drainage and bench services are likely to require the most frequent attention or modification during the life of the building and these should therefore, where possible, be separated from heating, lighting and ventilation services.

(c) The facilities required for commissioning purposes must be allowed for in the detailed design of the services (see Hospital Technical Memorandum No. 17: Commissioning of Hospital Engineering Services).

(d) More than one-third of the total area of the simplest form of laboratory layout (i.e. one with with central corridor) needs a high rate of ventilation at all times of the year, and this almost inevitably implies mechanical supply and extract ventilation.

(e) Corrosive, noxious, flammable pathogenic and sometimes radioactive materials are handled. In this connection the Highly Flammable Liquids and Liquified Petroleum Gases Regulations 1972 (S.I. 1972 No. 917: H.M.S.O.) and the Code of Practice for the Protection of persons against Ionizing Radiations arising from Medical and Dental Use, impose requirements for the protection of persons employed in places where such liquids, gases or radioactive materials are present. With regard to highly flammable liquids the Regulations cover the manner of their storage, the marking of storage accommodation and vessels and certain fire and explosive precautions. Where highly flammable liquids are held and/or handled anywhere in pathology laboratories the Regulations should be applied. Only the minimum of such liquids should be held outside the flammable goods store (see paragraph 58*(a)*).

(f) Highly ventilated areas should be grouped as closely together as possible.

Flexibility

76. The pathology department will be subject to growth and change and an imaginative layout of engineering services should take this into account. The capital costs of providing the flexible installation required (see paragraph 62) must be understood and appreciated at an early stage. The two most difficult services to provide with a reasonable degree of flexibility are ventilation and drainage, both of which even in inflexible situations need considerable space, the critical dimension usually being vertical depth. For example, a balance will often have to be struck between the wish to provide a sufficient volume of air (in terms either of dead space or of actual ductwork) to allow for a greater number of or change in the positions of fume cupboards and microbiological safety cabinets and the capital cost of so doing.

Alternative methods of distribution

77. *(a)* Vertical or horizontal systems of distribution (see Figure 13) may be used and each method has its own characteristic advantages and disadvantages arising from the combined effects of structure, cost and use of space. The service sub-mains may be loosely defined as the service runs between the main supply and the point at which the bench spines begin. The bench spines are the service runs along the bench which feed the outlets on the bench, together with that part of the drainage system associated with the individual bench. In a two-storey design vertical sub-mains might be fed from horizontal mains at high or low level, alternatively horizontal mains could be taken from vertical ducts at one or more points in the building.

(b) There are several variations on each basic method of vertical or horizontal sub-main distribution and some alternative systems are shown in Figure 14. These distribution diagrams are not intended to be comprehensive nor do they indicate specific services such as drainage and ventilation. They are related to a two-storey building form only; other problems and possibilities will arise with single-storey layouts or with laboratories integrated with other departments.

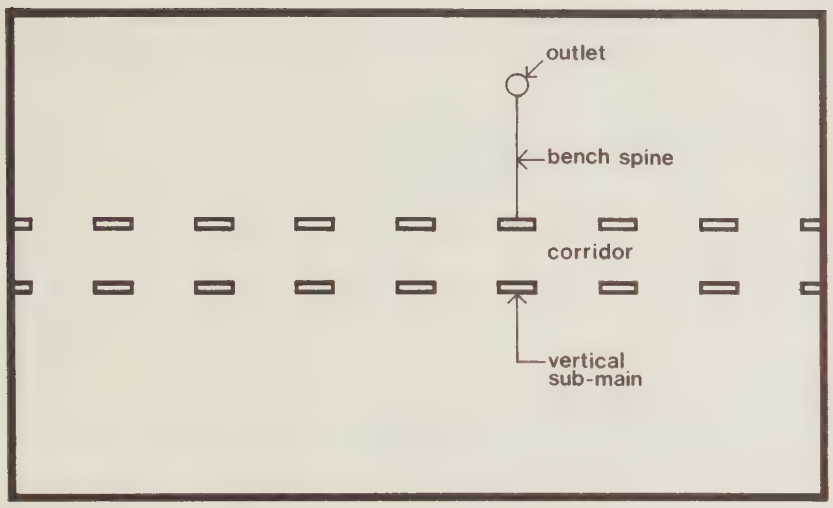
(c) The relative merits of the various alternatives are summarised in Table 5 below.

Bench services

General bench services

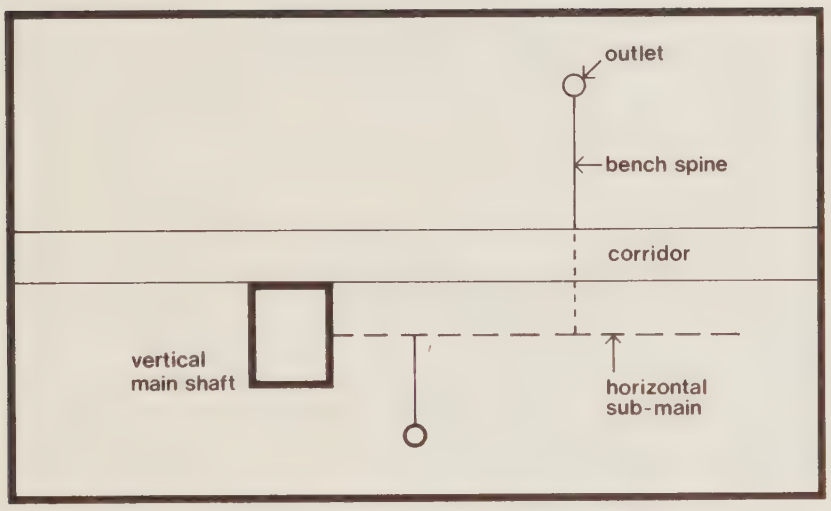
78. The essential distribution services may include the following:

(a) cold water
(b) town or natural gas
(c) compressed air
(d) rough vacuum minus 530 mb to minus 670 mb
(e) drainage
(f) electricity supply for socket outlets
(g) Adjustable lighting fittings (certain benches only).



VERTICAL SUB-MAINS

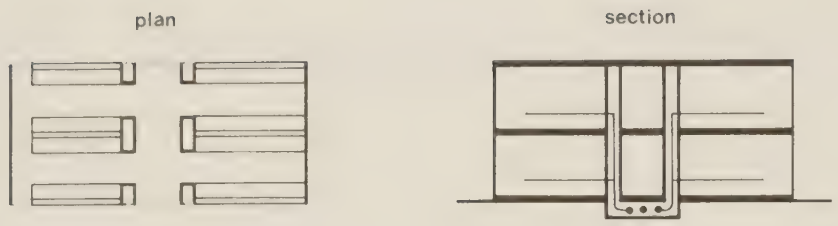
Arrangement of multiple small shafts with short branches.



HORIZONTAL SUB-MAINS

Arrangement with limited number of vertical shafts and long horizontal sub-mains.

FIGURE 13 Basic methods of service distribution (shown in plan)

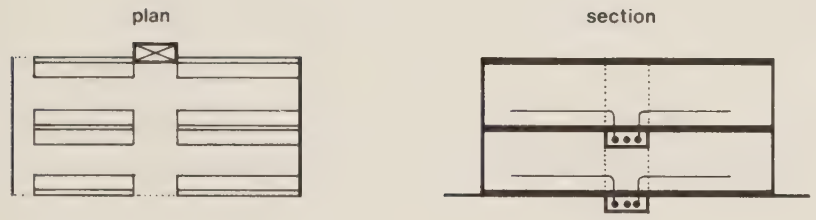


(a) Vertical sub-mains from a horizontal main at low level.

(b) Vertical sub-mains from a horizontal main at high level.

(c) Vertical sub-mains on the outside wall taken from a horizontal main at low level.

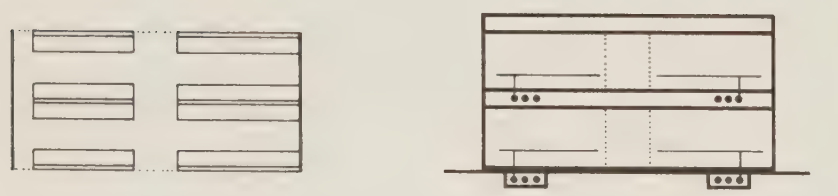
(d) Horizontal sub-mains in a dropped ceiling at each floor level with a vertical main at the end of the building.



(e) Horizontal sub-mains in a floor duct at each floor level with a vertical main at the end of the building.

(f) Horizontal sub-mains around the perimeter below window level. Vertical mains at the end of the building.

(g) A central channel or shaft for services and plant with the access corridor on the perimeter of the building.



(h) A complete sub-floor for the horizontal distribution of services.

(i) In a single storey building services might be distributed overhead exposed with floor ducts for draining, etc.

FIGURE 14 Alternative methods of distribution for engineering services

TABLE 5

Comment	√=GOOD		——=AVERAGE				X=BAD		
	(a)	*(b)*	*(c)*	*(d)*	*(e)*	*(f)*	*(g)*	*(h)*	*(i)*
Longitudinal (main) drainage runs easily accommodated	√	X	√	X	——	X	√	X	√
Lateral (subsidiary) drainage runs easily accommodated	√	√	X	√	√	X	√	√	√
Easy access to horizontal services at ceiling or floor level (i.e. not above/below/between ducts or in rooms)	√	——	√	X	X	√	√	——	——
Perimeter walls free for heating circuits	√	√	X	√	√	X	√	√	√
Avoids extra ducts in floors for drainage	√	√	X	X	X	X	√	√	X
Avoids waste of floor area or volume	——	——	——	√	√	√	——	——	√
Provides access for maintenance without causing inconvenience to users	√	√	X	√	√	X	√	X	X

The financial value to be placed against each comment above will vary with every laboratory design.

79. The following distribution pipes may be carried in the same ducts as the general bench services but will not ordinarily be available at every bench position:

(a) purified water
(b) drinking water
(c) hot water (flow and return in most cases).

Limited bench services

80. Some of the following services may be required at individual benches in the sections shown and typical rates of consumption are given in Table 6. At the early stages of design, it should be decided which of these should be piped and over what limited area. The local Chief Fire Officer should be consulted if it is intended to use those gases marked *(a)* from portable cylinders within the department. Acetylene is normally required for photometers only and if portable cylinders are to be used adjacent to each instrument they should normally contain sufficient gas for only one day's work. The cylinders should be installed in a well ventilated area, kept clear of naked flames and flammable materials and the supply should be obtained via a pressure regulator. Acetylene pipelines operating at pressures between 9 P.S.I.G. (0.6 Bar) and 22 P.S.I.G. (1.6 Bar) should be installed in accordance with the Chief Works Officer letter dated April 1978 (WKO(78)3). Some photometers need a supply at a pressure above 9 P.S.I.G. Acetylene pipe lines should be protected by flash-back arrestors, one being fitted as close as possible to the cylinder, the other as close as possible to the photometer. Isolating valves should be fitted at both ends of the pipe line; both valves should be closed when the apparatus is not in use and particularly at the end of the day. A non-return valve should be fitted at the apparatus end of the pipe line.

TABLE 6

Gas	*Sub-department using it*	*Typical total monthly consumption*
Oxygen *(a)*	Mechanised, Toxicology, Biochemistry, (Gas Chromatography)	45,000 litres
95% oxygen and 5% CO_2 mixture *(a)*	Mechanised, Biochemistry	1,000 litres
Hydrogen *(a)*	Bacteriology, Biochemistry (Gas Chromatography)	7,000 litres
Propane *(a)*	Mechanised, General Biochemistry	1,200 litres
Acetylene *(a)*	Toxicology, General Biochemistry, Biochemistry (Gas Chromatography)	1,200 litres
Carbon Dioxide	Histology, Bacteriology, Serology	15 kg
Nitrous Oxide	Biochemistry (Gas Chromatography)	Requirement varies over a limited range for each laboratory.
Nitrogen	Biochemistry (Gas Chromatography)	1,200 litres
Argon	Gas Chromatography and Toxicology in most cases	1,200 litres

Small quantities of other gases are used, including other mixtures of O_2 and CO_2, and these are supplied from portable cylinders.

Service mains for bench services—Design and construction

81. *(a)* The main piped distribution system should be provided with tees at every bay e.g. at 3·3m centres in the areas likely to be used for laboratory work. The tees should have plugged outlets where they are not required for immediate use.

(b) The cold water may be piped to local electric or gas water heaters for remote sinks if this would supply hot water more economically than the normal arrangement.

(c) Changing techniques and the availability of natural gas are causing and will continue to cause changes in the requirements for gases in the pathology laboratory. Although existing flame photometers are usually operated with oxygen, and either propane or butane, the newer ones operate on compressed air and natural gas. Existing flame photometers can usually be converted to burn natural gas, and when this conversion has been completed they can usually be operated on compressed air and propane until natural gas becomes available. Atomic absorption spectrophotometers may operate with flames of air/acetylene, air/propane or nitrous oxide/acetylene. They may also require other gases for different procedures.

(d) Very high temperatures are produced with the burning of nitrous oxide and acetylene in atomic absorption spectrophotometers. Damage arising from the heat can normally be avoided altogether by the proper design of the hood and the extract ducts, to ensure adequate dilution and cooling of the products of combustion. If there is any doubt about the temperatures likely to arise in the ducts from the use of this hot tall flame a special insulated duct may be necessary.

(e) The greatest possible care must be taken in the construction of the pipe system for miscellaneous gases both for the general bench services and for local bench services. The whole of the installations, from and including the gas regulators on the gas cylinders, up to and including the outlets on the benches should be provided, installed and tested on the lines recommended for medical gases and this work should be carried out by a specialist contractor. It will usually be advantageous to employ the same specialist contractor for the piped compressed air and piped vacuum installations. Guidance on the detailed design, testing procedures and maintenance of this class of installation is given in Health Technical Memorandum No. 22: Piped Medical Gases, Medical Compressed Air and Medical Vacuum Installation. In particular, pipe work and valves for oxygen must be de-greased. Non-return valves will be required in the service to any item served by more than a single gas. The compressed air pipe lines will need to be drained (see paragraph 127). In this respect they differ from medical compressed air pipe lines.

(f) Pipe lines to bench outlets may be of copper to British Standard 2871 1970 or stainless steel (En 58B) except that copper pipes should *not* be used for acetylene or purified water. Plastic tubes increase the fire hazard when used for laboratory gases and should not be used for the fixed pipe work.

(g) Terminal units of the type used for medical gases, medical compressed air and medical vacuum should not be used in the pathology laboratory. Bench outlets for town or natural gas should terminate in twin safety cocks with drop-lever or similar handles. Outlets for oxygen should terminate in needle valves, de-greased and suitable for oxygen use. Outlets for acetylene should terminate in copper-free needle valves. Outlets for other gases and for compressed air should terminate in needle valves, and outlets for vacuum should terminate in suitable diaphragm valves or needle valves. All these outlets should have hand wheels suitable for identifying the gas by shape as well as by an indestructible identification of the gas on the wheel itself (see British Standard 3202 Table 9). Front controls are not required for any bench outlets but are required for fume cupboards.

(h) A wash vessel must be installed at the bench position to remove acid vapours from any vacuum pipe line connected to an automatic analysing machine. See also paragraph 128.

Special requirements in deep plan laboratories

82. Deep planning will result in additional demands on the heating, ventilating and lighting services, although the reduced area of external wall will mean lower heat losses. More detailed consideration of the special servicing requirements of deep plans is given under the individual headings of the services in this Note.

Identification of pipe lines and valves

83. Attention is drawn to the importance of identifying by colour all pipe lines used for gases, as well as those for compressed air, vacuum, heating and drainage etc. In this connection reference should be made to British Standard 1710. Hand wheels of all valves should be permanently identified by shape as described in British Standard 3202 where appropriate.

Noise control

84. *(a)* The engineer and architect must jointly ensure that acceptable sound-pressure levels are not normally exceeded in any area and that privacy of conversation is assured in all consulting and patient-examination rooms, venepuncture rooms, principal offices and certain office/laboratories. This will be achieved by combination of the control of the sound-power at its source, and, where possible, by planning and by constructional techniques. The engineering plant, which will contribute significantly to the individual room sound-pressure level, will include the ventilating plant (fans, ducts, diffusers and grilles), washing and sterilizing plants, the cold-room compressors, the air-compressors, vacuum pumps and the waste disposal units. The specification for

items of equipment, such as centrifuges and shaking machines, should contain clauses setting limits on their sound-power levels. Speech and noise can travel along all service trunking, and supply and extra ducts. Special care is required to prevent this occurring in the rooms where privacy of conversation is required. Guidance on noise control problems is given in Hospital Design Note No. 4: Noise Control as amended by HN (76)126, and in BS 5720: 1979, Code of Practice for Mechanical Ventilation and Air Conditioning in Buildings. The design of internal partitions in relation to sound transmission problems is referred to in Section 3/1 of the Manufacturers' Data Base: Partitions. Adequate attention must be paid to the acoustics of rooms where loud-speaking telephones are to be provided.

(b) The design aim should be that the overall noise level anywhere in the laboratory when it is fully operating should not exceed 55dB(A) for more than 10% of the period of daily occupancy. The contribution the occupants make to the overall total is outside the designer's control, although design features can influence such noise and should therefore receive appropriate consideration. For the purposes of setting design criteria it is usual practice to assume that normal speech and activity by the occupants will generate half the overall noise; thus the design team should ensure that the total noise contributed by the equipment, services and extraneous sources does not exceed an L10 level of 52dB(A).

Mechanical services

Space heating

General design principles

85. *(a)* Space heating requirements should be calculated using the design temperatures and ventilating rates in Table 7, based on an outside temperature of minus 1°C.

(b) There will be no fabric heat losses from core rooms except on the top and bottom floors. No heating will be required in such rooms except for those on the top and bottom floors where background heating may be necessary unless there is adequate heat arising from the lighting and other equipment in the rooms.

(c) The heating should be controlled by zones but these must be arranged with care. Adequate space must be provided for the control valves, thermostats and by-pass circuits in the control room so that the sensing elements can observe the true water temperatures, where the hot and cooler water are thoroughly mixed.

(d) All control valves, thermostats, vents and drain valves outside the plant room should be permanently accessible to the maintenance staff from the circulation areas. This may not of course be possible in all cases.

(e) Radiators and finned tube heating should be fixed with sufficient clear space below to allow for the use of industrial floor maintenance equipment.

(f) Pipe sleeves and finned tube installation (as well as other services) should be sealed acoustically where they pass through consulting rooms, patient examination rooms and similar rooms where privacy of speech is required.

(g) Ordinary finned tube and fan convector heating should not be used in the media pouring area because of the need to minimise dust problems (see paragraph 111).

(h) If either ceiling heating or plenum heating has to be adopted it may be necessary to supplement this by a simple heated bar or pipe at cill level to counteract down draughts at the windows. This may be particularly necessary on northern and eastern aspects unless double glazing is provided.

Selection of a suitable space heating system

86. *(a)* For the main areas in a pathology laboratory the most economical heating installation can be planned either with conventional hospital pattern radiators or with cill line finned tube heating, provided the laboratory is planned with the benches at right angles to the perimeter walls as recommended in this Note*. If the benches are arranged along the perimeter wall neither of these systems is likely to be satisfactory because of the excessive heat to the legs of workers at the benches and because of the need to provide space-consuming grilles in bench tops or behind benches.

*This Building Note is costed on a simple solution comprising perimeter heating with hospital type radiators and with mechanical ventilation (100% heated fresh air) for those areas where mechanical ventilation is essential. Simple single-corridor and double-corridor deep-plan layouts have been costed.

TABLE 7

Accommodation	*Internal temperature °C*	*Air change rate per hours for heat loss calculation**
Venepuncture rooms, examination rooms and staff rest rooms	20	3
Office/laboratories, chief technician's office, other laboratories, preparation areas, workshops	18	3
Staff duty, reception, general office, circulating spaces, toilets, lecture room	18	2
Wash-up and sterilizing room, disposal	16	½
Stores, cleaners' equipment room	10	½

*Additional heated air will be required for ventilation, as in paragraph 89.

(b) If finned tube heating is employed it should be of the type which allows the optional provision of an adjustable damper in each building bay. Finned tube systems should have fixed front panel sections at each building bay suitable for incorporation in a partition wall. Continuous front panels are not necessary if the benches are to be carried right up to the perimeter wall but in this case the sections of pipe under the ends of the benches must be lagged and protected from mechanical damage, and it must be possible to remove all front panels covering the actual finned tube without moving the benches, so that the finned tubing itself can be regularly cleaned without difficulty.

(c) Ceiling heating allows freedom of planning of the use of floor space but if floor-to-ceiling cupboards are to be used they may mask the heating surface unless this is allowed for in the design of the heating system.

(d) Plenum heating may sometimes be the most effective and economical solution, especially for deep-plan laboratories or those laboratories where extensive mechanical ventilation becomes necessary because of the difficulty of providing adequate natural ventilation. It may also be used, with the air at a lower temperature, to supplement any conventional perimeter heating or ceiling heating installation. Plenum heating reduces the flexibility of design since the heating requirement of a given floor area is not directly related to the ventilation needs of the area and a highly ventilated area may not be sufficiently heated if it is later converted to provide accommodation where low ventilation rates are required.

(e) Fan convectors with filtered fresh air intakes and individual room thermostats may be used in the sterilizing plant room, the wash-up and sterilizing room and the library. If these rooms are mechanically ventilated the convector fans may be interlocked with the main supply air fan and the rating of that fan may be correspondingly reduced where it is economical to do this. Filters in fan convectors must be readily accessible for maintenance purposes. They should be capable of dealing with air of 100 per cent relative humidity but it must be recognised that it may not be possible, at reasonable cost, to obtain from these filters the degree of filtration specified for the filters on the main air supply system in paragraph 95.

Mechanical ventilation

General design principles

87. Factors which will influence the need for and the extent of mechanical ventilation include deep planning, the level of extraneous noise, external air pollution, high-rise construction and excessive exposure to high winds. The installation of fume cupboards and microbiological safety cabinets necessitates an adequate provision of heated and filtered make-up air supplied at a rate to ensure air flow into laboratories and Category B1 accommodation from less hazardous areas. This may be supplied directly to the laboratory in which they are installed and/or drawn via transfer grilles from adjacent rooms or corridors thus assisting in producing the desired direction of air movement; this pattern of air movement is similarly appropriate for paramedical workshops and the disposal room. It will be normal practice to rely on the main mechanical ventilation supply system to provide the 'make-up' air required. The ventilation systems should be 100% total loss except for the library, lecture room, offices etc. In the unlikely event that the heat gain within the Category B1 room requires a supply air volume in excess of the extract volume provided by the microbiological safety cabinet, then additional extract provision should be made to ensure the desired pattern of air movement. Microbiological safety cabinets exhaust via H.E.P.A. filters and it is essential that they can be switched on or off by the operator for use intermittently to reduce the frequency at which filters must be changed, and to permit sealing of the cabinet for fumigation if a spillage occurs inside the cabinet. In a fully air conditioned/mechanically ventilated building it is important that the desired air flow pattern is maintained whether or not microbiological safety cabinets are running. Microbiological safety cabinet fan(s) should be interlocked so that, automatically, either an alternative extract system can come into operation or, in the laboratories or room(s) where separate supplementary extract is provided, the extract volume can be varied by the appropriate amount to compensate for stationary microbiological safety cabinet fan(s). Fume cupboards can be run continuously as part of the extract system. Four distinct ventilation problems to be considered follow:

(a) Those associated with human habitation (odours, smoke and dust).

(b) Those associated with the activities of the department (odours, infectious aerosols, gases, vapours, fumes and dust)—some of these necessitate working with material which can be toxic, infectious, corrosive, flammable or otherwise hazardous and must be undertaken in microbiological safety cabinets (Class 1) or fume cupboards as appropriate. Microbiological safety cabinets must have individual separate extract systems. Fume cupboards for similar processes may share a common extract system but, in view of the small numbers required for pathology laboratories, separate systems are preferred.

(c) Heat gains by apparatus—these will be high in the wash-up and sterilizing areas and relatively low elsewhere. Hoods should be used where appropriate to reduce the effect on the room environment.

(d) Solar heat gains.

88. The heating effect of lighting fittings, plant and any hot pipes in deep plan areas, while not an embarrassment in cold weather, will cause internal temperatures to rise in warm and possibly mild weather since the ventilating air at outside temperature cannot carry away the heat without the room temperatures being increased. Refrigeration plant should be included in the ventilation scheme where calculations show that without an excessive number of air changes the internal temperatures will rise more than about 3°C above outside temperatures. The refrigerating plant should be of sufficient capacity to off-set these heat gains and maintain the internal rooms at external shade temperatures. With refrigeration, the number of air changes required will depend upon the heat gains and the temperature of the conditioned air. The temperature differential between entering air and room air should take account of the method of air distribution.

89. The following mechanical extract ventilation will be required.

TABLE 8

General areas	*Requirements*
Toilets (if internal)	10 air changes per hour
Wash-up and sterilizing room	Hoods over sterilizer doors, washing machines, sinks and dryers, or equivalent room air changes
Sterilizing plant rooms	About 10 air changes per hour *(i)* to remove heat and vapour
Workshop, Disposal	6 air changes per hour
Core areas and deep-planned laboratories	6-10 air changes per hour
Lecture room	See paragraph 90
Laboratory areas	*Requirements*
Formalin store (sealed specimens)	6 air changes per hour *(ii)*
Specimen cutting and tissue processing	6 air changes per hour *(iii)*
Fluorescent Microscopy	6 air changes per hour
Category B1 Laboratory	Microbiological safety cabinets (Class I). 10 a/c/hr. Must be mechanically ventilated. *(iv)*
General Laboratories	Microbiological safety cabinet(s) (Class I) Fume cupboard(s) *(ii)* Hoods over flame photometers *(ii)* Atomic Absorbtion Spectrophotometer *(v)* 6-10 a/c/hr. Could be naturally ventilated but make-up may be required, for fume cupboard and microbiological safety cabinets.

(i) Must be related to the heat loss from the plants as well as to the vapour produced in and around it in the plant room.
(ii) May be at high temperature, toxic, flammable or corrosive.
(iii) Balanced ventilation.
(iv) Negative pressure ventilation.
(v) Flame guard may be required.

90. If a lecture room is provided and the room needs to be blacked out for long periods at a time it should be provided with mechanical ventilation. Air changes should be calculated at the rate of 0·3m³/min per person if smoking is not permitted, or 1·0m³/min per person if smoking is permitted. As this room is unlikely to be in continuous use, the room ventilating system may be independent of the main system and may consist of extract at high level with fresh air inlets behind radiators or in fan convectors. If fan convectors are used their fans and the room extract fans may be electrically interlocked and a clearly labelled ''Ventilation Control Switch'' should be provided near the main entrance to the room for the fan convector and extract fans.

91. The main supply air plant, the normal extract plant and the main toxic extract plant should each consist of two identical sets of equipment, capable of operating continuously on 60 per cent of the design load. Dampers should be provided, as necessary, for single-set operation.

Location and general design of main ventilating plant

92. The supply air plant and ducting may be incorporated with that for other sections of the hospital where this would result in economy. The fans should normally re-start automatically on the restoration of electricity supply after an unscheduled interruption. Much of the extracted air is likely to be corrosive, toxic or flammable; the extract system should not therefore be integrated with that for other sections of the hospital. Careful consideration must be given to the problems of transmission of ventilating plant noise, location of fresh air intake and termination of extract ducting. Proper access for maintenance for each item of plant must be available. Economy in distribution costs and problems of fire protection will also influence the plant site selection. Heavy walls and ceilings (or floors for roof mounted plant) should be used to separate the plant from areas sensitive to noise and vibration; the transmission of vibration to the balances and microscopes, for example, must be prevented. The plant room must be well ventilated and the plant will need protection from the heat of the sun and from frost. Where ducts pass through walls or floors care must be taken to seal them, to prevent transmission of noise and spread of fire. See Hospital Design Note No. 4: Noise Control and Health Technical Memorandum 81, 'Fire Safety in New Health Buildings' (in preparation at the time of writing).

Supply air temperature

93. Where radiators or convectors are provided or radiant heating is used to meet the fabric and air in-leakage loss, the supply air heating installation should be thermostatically controlled to maintain its temperature in winter at approximately 20°C. A higher temperature will be required if plenum heating is employed. Summer cooling is not generally required except in some deep plan laboratories and in the Category B1 room.

Air intake

94. The louvres and screens are normally provided by the builder and are designed to exclude rain, flies and ash but care must be taken to ensure that the air is taken from the highest possible level, the inlet is properly orientated and is adequately proportioned. Automatic dampers should be provided to close the intake when the plant is idle so as to prevent excessive cooling of the ventilated rooms and plant during silent hours. For plants having a capacity exceeding about 10m³/sec the dampers should be interlocked with the supply air fans.

Supply air filters

95. Primary filters of the dry type, capable of removing at least 90 per cent of all particles down to 5 micron size, should be provided up-stream of the supply air heaters. The filters may be of the conventional panel type or of the automatic roll type, and must be capable of dealing with air at 100 per cent relative humidity. The selection will usually be made on the basis of relative total cost (including replacement cost), dust-holding capacity and operating resistance. Secondary filters of the same type will be needed in most urban areas and, if

they are of the roll type, these may be advanced manually. Filters should be tested with test-dust No. 2, in accordance with British Standard 2831. If roll type filters are used the motor for the main filter movement should be controlled by a pressure-differential switch and have an end-of-spool indicating lamp and alarm operating in an approved place and an inching switch for operating the filter during servicing. A pressure-differential indicator should be provided across panel-type main filters. Filter housings must be of galvanised or equal rust-resisting construction and the whole should be of a design ensuring proper seating of the filter medium, thus preventing the by-passing of any outside air. They should be of a type in which the frame sealing can be efficiently maintained throughout the life of the installation. The filter should be of a type that will not be damaged by any inadvertent back-draught when the plant is shut down. Provision must be made to prevent the icing of the filter due to freezing fog, e.g. by the provision of anti-frost heaters. Care must be taken to ensure that all air filters can be replaced without difficulty, and without disturbance to the routine work of the laboratory.

Air heater battery

96. The heater should be thermostatically controlled, with over-riding frost control.

Air cooling plant

97. If plant is required in summer for cooling the air supplied to any core rooms, this may be in package form and located in the vicinity of these rooms but on a by-pass of the supply air duct to them. The plant should preferably be in the form of two sets each capable of 60 per cent of the full load requirement.

Supply air fans

98. Slow speed centrifugal fans are likely to be the most suitable for this purpose as they combine adequate efficiency with low specific noise level (providing the casing is well designed). Two-speed fans are likely to be necessary only if plenum heating is adopted; these will make it possible to reduce the heating loading during silent hours. Vee belt drives should be easily accessible for motor and belt changing and easily adjustable, the fan pulley should be overhung in order to simplify belt changing. Fans and driving motors must be completely isolated from the structure by anti-vibration mountings, they must also be separated from the duct work by heavy flexible connections. Where necessary a mass foundation should be provided (see BS5720:1979 Code of Practice for Mechanical Ventilation and Air Conditioning in Buildings).

Silencers

99. With good design and proper selection of fans the performance of the silencers is governed by the fan specific noise level and the attenuation achieved in the ducts themselves; it should be specified as the ''substitution'' or ''insertion loss'' performance. Proper space must be provided for the silencer in the plant room.

Supply air ducts

100. These may be of builders' work, where this would ensure the proper distribution of air (for example, by the use of ceiling voids), or of any of the materials referred to in BS5720. Close co-operation between architect and engineer is essential if builders' work ducts are used, so as to ensure that the surfaces are smooth and that all joints in them are properly sealed. Where necessary, air ducts should be insulated and protected from the weather. They should not normally be lined for sound attenuation purposes; terminal attenuators should be used where noise control is necessary. Sheet-metal ductwork should be in accordance with the appropriate specification of the Heating and Ventilating Contractors' Association.

Dampers

101. Fire dampers should be provided if and where considered essential under the current Building Regulations or by the local Chief Fire Officer; each should be fitted with a micro switch connected to a signal lamp or alarm to indicate when the damper is closed. Dampers in extract ducts, and all their associated links and bearings must be corrosion-resistant. Balancing dampers in main ducts should be substantially built and of multi-leaf design, in order to minimise the generation of noise.

Diffusers and grilles

102. *(a)* Supply diffusers and grilles should be designed and disposed so that the velocity of the air lies between 6 and 12m/min in the space up to 2m above the floor level in any part of the laboratory which may be occupied by staff. This will involve great care in the design for areas requiring 10 or more air changes per hour. In particular the supply air distribution system should not spoil the unidirectional air flow pattern required for fume cupboards and microbiological safety cabinets. In general, supply air ceiling diffusers or grilles should not discharge directly towards a fume cupboard or microbiological safety cabinet face unless the terminal velocity is sufficiently low so as not to affect the air flow pattern. In practice this will necessitate positioning the grilles or diffusers several metres from the front face of a fume cupboard or microbiological safety cabinet. The effect of the induced air flow generated by the method of supplying air to the room should be considered in the positioning of air distribution equipment. It is undesirable to have supply air grilles discharging over the top of a fume cupboard where the induced air flow is likely severely to disrupt the air flow pattern. The high air change rates resulting from multiple installations or single installations in small rooms necessitate careful selection of the method of supplying air to the room. Any consultants' rooms and patient examination rooms having supply diffusers should also have extract grilles, or if this is uneconomical, it may be necessary to employ transfer grilles made sound and/or vision proof. Similar provision must be made for any room in which privacy of speech is required. Transfer grilles should not be fitted in fire compartment walls or doors. Transfer grilles should be fitted in the walls or doors of those rooms which are provided with supply or extract only (either from the extract system through grilles, or microbiological safety cabinets and/or fume

cupboards) or where additional air is required because of the large volumes being extracted. They must be of sufficient size so that opening or closing of any doors between the adjacent areas does not affect performance of any microbiological safety cabinet or fume cupboard installed in the rooms. A damped door closure mechanism should be provided.

(b) Transfer grilles should not be provided in the specimen cutting and tissue processing rooms or in other rooms where malodorous processes are carried out; balanced or slightly negative pressures are required in such rooms.

(c) If diffusers are used care must be taken to ensure that they are fitted with deflectors and key-operated volume control dampers so as to give proper directional and volume control. All adjustments on these diffusers must be lockable so that the setting is not disturbed when they are cleaned.

(d) Internal lavatories, dirty utility and sluice rooms should have mechanical extract grilles at low level and supply air diffusers at high level. Diffusers and grilles in chromatography areas and in the vicinity of automatic analysers should be specially protected to resist corrosion. Epoxy or epoxy/phenolic paint will usually give sufficient protection to most metals subject to corrosive attack, but where severe corrosion may occur special plastic covering may be necessary.

(e) The velocity of the air through diffusers and grilles should not be such as would add to the noise level transmitted.

(f) Air flow indicators, in ribbon form, should be provided as necessary.

Extract ducts

103. *(a)* It is desirable to design extract duct routes to avoid passing into other fire compartments. Where this is unavoidable the duct should be given appropriate fire resistance or be provided with fire dampeners. Extract systems for microbiological safety cabinets and perchloric acid fume cupboards must not have fire dampeners and ducts must be provided with fire protection. The extract ducts for microbiological safety cabinets and fume cupboards should be constructed of the following materials:

i. PVC. (Circular section PVC is the preferred material for microbiological safety cabinets. The choice of material for fume cupboards will be dependent upon the chemical processes involved.)

ii. Asbestos reinforced thermoplastic PVC laminates.

iii. Metal with PVC coating internally (provided the operating temperature is never likely to exceed 60°C) or other suitable protective coating.

iv. Epoxy coated asbestos cement.

v. Stainless steel.

(b) None of these materials is resistant to all the organic liquids and acids which may be used in a laboratory but the more these liquids and their vapours are diluted, the more safely they can be handled. These ducts should be graded so that they drain towards the hood, cupboard or grille. Other materials may be used, providing they have equal or better resistance to such attack and have a flame-spread characteristic not lower than class "O" in Regulation 15 of the Building Regulations 1972.

(c) If asbestos cement or metal ducts are used these should be constructed in accordance with the recommendation in the Institution of Heating and Ventilating Engineers Guide. If asbestos reinforced thermoplastic PVC laminates are used these should be constructed as indicated in Appendix 1 to this Building Note.

(d) Small PVC service ducts, not exceeding 100mm in diameter may be used, provided they are well drained and exposed to view (except where they pass through walls) and provided the operating temperature is never likely to exceed 60°C. No such PVC service ducts may pass through floors if they are compartment floors within the meaning of the Building Regulations 1972. Conventional methods may be used for the construction of all other extract ducts. It may be possible to reduce the amount of spur ducting, especially in deep planned areas, by providing continuous grilles of corrosion-resisting material in the lower face of the main extract duct, if this is finished flush with the corridor ceiling. Normal extract ducting should be used in rooms where smelly processes are carried out.

Extract silencers, fans and louvres

104. These should be of corrosion resisting material but otherwise as described in the corresponding paragraphs for supply air equipment. Care must, of course, be taken to ensure that the extracted air is not directed into the fresh air intake under *any* wind conditions.

Microbiological safety cabinets, fume cupboards, hoods and horizontal laminar flow cabinets

Scale of provision

105. These items should be provided on the scale suggested in Appendix 2 and with the fittings indicated. This suggested scale should not be reduced in a department which is fully integrated with a P.H.L.S. laboratory. Fume cupboards should not be provided for work which should properly be done in a microbiological safety cabinet.

Details of design and installation

106. *(a)* Microbiological safety cabinets and fume cupboards rely on a stable undirectional inward air flow to provide protection of the operator. Their position within the laboratory must be such that an area at least 1 metre undisturbed by anyone other than the operator, is preserved in front of them. In particular they should be positioned away from circulation areas. They are susceptible to the effects of other items of equipment; in particular the distance between them and the face of any other safety cabinet, fume cupboard or hood, should not be less than 3 metres. Microbiological safety cabinets and some designs of fume cupboards do not operate effectively when positioned with one side against a wall surface or other obstruction which is closer than

300 mm. They must not be positioned in any direct line of draughts from doors or, when natural ventilation is provided, windows. Windows providing natural ventilation in the vicinity of fume cupboards and microbiological safety cabinets should be of the hopper type. The possibility of a fire or explosion which may not be contained by a fume cupboard must always be considered. A fume cupboard should not therefore be sited in a position where exit from the work space to an escape route will necessitate passing directly in front of it.

(b) All microbiological safety cabinets must be in accordance with BS 5726. Each microbiological safety cabinet is required to have a separate extract system and fan, the most suitable material being circular section PVC duct work.

(c) Fume cupboards should be of the aerodynamic type designed to operate with a face velocity of 0·5 m/s* by means of a bypass sash arrangement irrespective of the sash position. They should be provided with integral fluorescent lighting. Fume cupboards into which air is introduced directly are not recommended because of the possible contamination in the event of fan failure and the discomfort which can be caused to the operator in cold weather if the air is unheated. It would be possible to group cupboards for similar processes together with a common extract system but, in view of the modest numbers involved in pathology laboratories and the variety of processes carried out, it is preferable to provide each with a separate extract system and fan. Fume cupboards for certain processes must have a separate extract system e.g. where perchloric acid is used.

(d) Hoods are required for the extraction of toxic fumes and odours and the control of high heat gain and vapours, e.g. for gas chromatographs, the cutting-up bench, atomic absorbtion spectrophotometers, flame photometers, the food laboratory, muffle furnace and sterilizing room. They should be designed to ensure satisfactory performance with the minimum air flow. Hoods required for the control of heat gain and vapours may be connected to the normal extract system when it is convenient to do so. Extract of toxic fumes, including hoods for gas chromatography equipment and flame photometers, must be by a separate system and fan. Because of the high temperatures, the hood and a short section of duct work for flame photometers must be of stainless steel, or glass fibre reinforced PVC where corrosion of stainless steel is likely. The short section duct work may connect into a PVC branch duct provided the temperature is reduced by dilution; alternatively an air bleed at or before the connection can be provided. Some guidance on the design of hoods is covered in the CIBS Guide publication B2 and B3.

(e) It will be necessary to have one or more of the microbiological safety cabinets and one or more of the fume cupboards available for use at any time of the day or night and when the laboratory is closed, e.g. at weekends. The provision of background i.p.h.w. heating may be appropriate together with the facility for the operation of any associated ventilation plant. Work undertaken in the Category B1 room must be carried out only with all systems serving the room operating. Where make-up air is provided by mechanical ventilation (either from an independent system or from a main supply ventilation system) a supply air failure warning system must also be provided. If any extract system fails in the Category B1 room or any fume cupboard, the supply system must be capable of being shut down or reduced by the appropriate amount to prevent pressurisation of the rooms and possible contamination of adjacent areas.

(f) The ventilation control systems must ensure that, under normal operation, the systems will continue to run for a period of time after work has finished to purge any remaining contaminants. (The systems should also be run before work commences.) This feature should also be provided for microbiological safety cabinets which are operated intermittently.

(g) Each fume cupboard discharge must terminate well above roof level to avoid the possibility of effluent being carried down the leeward face of a building, possibly re-entering the building through open windows at a lower level, and be clear of any opening windows in an adjacent building or other air inlet. The fans should be installed as near as possible to the termination of the duct thus maintaining the maximum amount of ductwork at a negative pressure. In certain circumstances, e.g. on a congested site where there are adjacent buildings with opening windows, or where downdraft occurs, it may be necessary to increase the height of discharge ducts to achieve adequate dispersal. To optimise the dispersal of fumes a collection duct and tall stack may be considered where there would otherwise be a requirement for a large number of separate stacks (the optimum height of the stack may have to be established by carrying out an air tunnel test). The individual fume cupboard exhaust system should discharge via non-return dampers into such a collection duct. The collection duct should have a large cross sectional area to minimise its effect on the individual exhaust systems and be open to atmosphere up stream of the first connection and be designed to have a total air volume at least equal to the combined individual extract systems. Individual fume cupboard extract systems either discharging directly to atmosphere or into a collection duct do not require duplex fans. A collection duct, however, is designed to provide dispersal of effluent for a number of individual extracts and should therefore have duplex fans with automatic change-over.

(h) The exhaust from hoods may be discharged into a collection duct, if one is to be provided, for fume cupboards but there is no advantage in treating the general extract in this manner, separate discharge being preferred.

*For certain classes of fume a minimum mean velocity higher than 0·5 m/s may be required to satisfy statutory or other requirements, e.g. chromatography spraying requires a velocity of 0·9 m/s.

(j) The discharge from microbiological safety cabinets is rendered microbiologically clean by virtue of the filter and the discharge to outside provides additional safeguards in the event of filter failure by dilution of any penetrating material. In view of the hazard involved it is usually sufficient to provide short discharge ducts to outside through the wall (or window) or through the roof. BS 5726 permits the installation of microbiological safety cabinets with integral fans provided that the extract ductwork can be kept short (less than 2 metres); such an installation is likely to be noisy and is not recommended for installations in new buildings. Roof level discharge wherever practicable is preferred, provided that this does not result in extensive and complicated extract ducts, since it removes much of the uncertainty over air re-entering the building through adjacent open windows. In such an installation the extract fan should be situated separate from the cabinet and close to the discharge end to maintain the duct under negative pressure. It is not necessary to resort to tall stacks (or a collection duct system) but the discharge should be kept several metres from ventilation inlets, opening windows in adjacent buildings etc.

(k) The corrected mean noise level of any microbiological safety cabinet, fume cupboard or hood when operating under its noisiest condition should not exceed 52dBA. The maximum noise level 1 m from any ductwork associated with the apparatus should not exceed 50dBA.

(l) The life of the filters on all types of safety cabinets will depend upon how much the cabinet is used and the cleanliness of the room air. Their life can, in most cases, be greatly extended by the fitting of pre-filters. Typical pre-filters need servicing every 8 weeks and when they are used the main filter may last 3 or 4 years. Changing the filters on a safety cabinet is a potentially dangerous procedure and should be carried out after fumigation: reference should be made to Public Health Laboratory Service Monograph Series No. 6: 1974: Revised 1977. The air flow rate across the face of all safety cabinets and fume cupboards should be tested by anemometer every three months.

(m) Laminar flow work stations may be required for media preparation. They operate by drawing air from the laboratory and discharging filtered air unidirectionally over the work space. THEY DO NOT PROVIDE PROTECTION OF THE OPERATOR.

Ventilation of subsidiary rooms

Core rooms and other minor internal rooms

107. Internal toilets, waste disposal collection rooms and similar rooms should be connected to a normal extract duct but a tempered supply of air can often be obtained without excessive draught or noise by fitting transfer grilles in doors or walls connecting such spaces to corridors etc. It will not normally be necessary to cool the ventilating air for any internal toilet.

Sterilizing plant room and wash-up

108. Ventilation is required for the removal of heat from the sterilizing plant area and for the removal of vapour and heat from the wash-up area. Untempered fresh air should not be admitted to the sterilizing plant room area because of the risk of damage by condensation and frost when the plant is shut down at night or at weekends. Independently tempered air supplies should be provided to each of these areas if the rest of the laboratory has plenum heating with a single duct system.

Formalin rooms

109. Specimens should be stored in sealed containers and not in open tanks in order to reduce the level of formaldehyde in the atmosphere. In some laboratories it may be necessary to provide continuous extract ventilation by separate fans for the formalin store. This arrangement should be avoided if possible, unless the users agree to the room being ventilated by the opening of windows in the event of the failure of the fan. A duplicate fan arrangement is required where it is absolutely essential to provide continuous mechanical extract ventilation. The door leading to the formalin room should be fitted with a flap valve at low level to prevent any flow of air from the formalin room.

Fluorescent microscopy room

110. This room must be darkened when in use and it is usually in the core area. It will not normally require mechanical ventilation since it is not in continuous use. If it is on an outside wall it can usually be naturally ventilated by light-proof louvres.

Media pouring room

111. The media pouring room requires balanced mechanical ventilation, with an extract fan providing a small even, draught-free and dust-free flow of air over the poured plates while they gel. The rate of flow of the supply air should slightly exceed the capacity of the extract fan. A lightweight flap valve should be fitted in the door so as to maintain a slight pressurised condition in the room when the door is closed. If a separate *supply* air fan is provided it should be fitted with filters and a heater on the lines indicated for the main air supply system. Such filters must be readily accessible for maintenance purposes.

Venepuncture rooms

112. These rooms must be adequately ventilated to carry away ether fumes but this can normally be achieved by natural means.

Dark rooms (additional accommodation)

113. Small processing dark rooms can be ventilated naturally through lightproof inlet and extract louvres. The airing probably needed at intervals can usually be achieved by leaving the door open.

Extract fan motors and fans

114. All motors for extract fans should be totally enclosed and mounted outside the duct in accessible positions. The extract fans themselves must be corrosion resisting.

Domestic water installations

Hot and cold water

115. *(a)* These are normally provided by connection to the main services of the hospital. For individual or isolated laboratories the cold water storage should be sufficient for 24 hours supply. The hot water storage capacity should be based on meeting the maximum requirement for two hours, the calorifier battery rating should be based on a 3 hour recovery period. Laboratory bench sinks do not normally need hot water supplies but all wash basins and wash-up sinks need hot and cold water supplies. Hot and cold supplies will be required for each glassware washing machine. Cold supplies are required for each autoclave. Cold supplies are also required for each waste disposal unit and slop-hopper but these supplies should be taken from break tanks. Cold water pipes should be insulated where they pass through unheated areas; the insulation must be of a type that is impervious to moisture, i.e. vapour-sealed externally. The laboratory should be supplied by one or more separate cold down feed pipes serving the laboratory only. Each pipe should be vented by a pipe of the same size, carried over the service tank. Horizontal branches should be taken off near the ceiling level to serve the floor below but not to serve the floor above.

(b) The temperature of the methylene blue water baths in the public health laboratory must be maintained at 20°C±1°C. The cold water supply to these baths may be taken direct from a cool underground main or from an insulated cool tank supplied direct from such a cool main and insulated throughout its length. This source may also be used to supply the dark room if cold water at low temperature is required for photographic film processing.

Drinking water supplies

116. A drinking water tap should be provided in each patient examination room, venepuncture room and treatment room and in the staff room. A drinking-water fountain should be installed in toilet areas, where essential. A supply of drinking water should also be taken to the boiler used for making beverages and/or the vending machine in the staff room. Supplies should be taken direct from the mains or from protected storage tanks. The size of drinking water pipes should be kept to the barest minimum and the pipes should be properly lagged in ducts and voids, where necessary, to keep the water cool.

Emergency showers

117. Emergency drenching showers should be provided at four strategic positions, for use by persons in the event of acid spillage or clothing fires. The supply of cold water to the showers should be controlled by plug cocks operated by chains. The floor below the showers should be drained into gullies.

Domestic water pipe fittings

118. Corrosion resisting laboratory type fittings of a type referred to in British Standard 3020 will be required for laboratory sinks; normal pillar taps will be adequate elsewhere. Elbow or wrist operated spray mixer taps may be used for washbasins. Water outlets should terminate well above sinks and washbasins to prevent contamination and to facilitate the filling of large containers at the sinks. It may be necessary to provide a filter near the cold supply taps in the dark room if film processing is carried out in the room. Foot operated taps should be provided for the water supply fittings for any slop-hoppers. Dual flush systems should be provided for women's lavatories. Water taps for benches should not be fitted with screwed outlets.

Purified water installation

Purified water production

119. Either distilled or de-ionized (de-mineralized) water will be required for limited general use; a very small quantity of even more highly purified water will also be required. The ordinary purified water will be used mainly for rinsing purposes at the washing up sinks and in the glassware washing machines. The total requirement may be of the order of 450 to 700 litres per day, made up as follows:

TABLE 9

Accommodation	*Litres per day*
Wash-up	350-550
Biochemistry laboratory	100
All other laboratories (total)	25

120. The laboratory will normally produce its own supplies by means of stills or by conventional de-ionizing plant, or by barrel de-ionizers (leased or owned), or by cartridge type de-ionizers. De-ionizers should be of the mixed bed type and not of the twin bed type. Condensed steam from the boiler plant is unlikely to be suitable for the purpose. The small quantities of very highly purified water required are usually obtained by passing some of the ordinary purified water through another small cartridge type de-ionizer. Small electric stills may be provided in certain departments as they will also serve as general stand by equipment.

121. A study of the technical features and operating costs of the various alternative methods now available for producing purified water indicates that conventional de-ionizing plants, operated and maintained by the laboratory staff, currently offer the most economical solution for most laboratories. No further reference will therefore be made in this document to the other methods of producing purified water. The layout of the de-ionizing plant must be carefully considered at an early stage so that the appropriate static head is available at the plant itself and at the purified water storage tank which follows the plant. Mixed bed de-ionizing plants can produce water equivalent to and sometimes better than that produced by stills, without the need for water solfteners, but in the size required they are not equipped for automatic regeneration. They need no steam or gas supplies but compressed air is used during the regenerating cycle and this will be obtainable from the pathology laboratory installation or from a built-in compressor. A typical plant needs a supply of mains water at a pressure of 0·6 bar for its operation and must be continually attended for about 1¼ hours during the regeneration period.

A plant requiring regeneration once daily will generally be adequate for most laboratories. Hydrochloric acid and caustic soda are used for the regeneration. The effluent during this procedure is in turn acid and alkaline in nature and must be dealt with accordingly. Normal care must be taken in the handling and storage of the regenerating materials and the makers supply the equipment needed for this purpose.

Storage tanks and distribution systems for purified water

122. Stainless steel (En 58B) or polythene (British Standard 1793) storage tanks should be provided to hold, say, 8 hours supply. The tanks must be specially designed to maintain the purity of the stored water. They should be air tight and ventilated by means of an absolute filter similar to that fitted to porous load sterilizers (see British Standard 3970-Part I): a non-return valve should be fitted to the overflow pipe from the tank.

123. A typical large laboratory glassware washing machine uses up to 32 litres per cycle but this must be supplied by large bore piping to enable it to flow at the rate of 364 litres per minute. The purified water storage tank should therefore be sited where it can supply this demand most efficiently and economically. A small storage tank of similar design may also be provided for the biochemistry laboratory, where it can supply the direct needs and also act as a storage tank for the supply to the cartridge type de-ionizing apparatus used for producing the very small quantity of very highly purified water required in this laboratory. Distribution pipework may be of the same grade of stainless steel or high density polythene and valves should be of a type designed to handle water of this quality. The distribution pipework and storage cylinders must be capable of being completely drained. No general distribution system should be provided. The following scale of outlets is recommended:

TABLE 10

Accommodation	*Scale*
Wash-up	1 outlet for each washing machine 1 outlet for each sink
Chemical pathology—chemical preparation bay	3 outlets on wet preparation bench 1 outlet for each atomic absorption spectrophotometer
Mechanised section	2 outlets

Great care is required in the construction of the purified water distribution system in order that the purity of the water may be maintained. A final flushing with the purified water itself will usually be adequate to ensure purity at the handing over stage, if appropriate care is taken when the installation is constructed.

Steam supplies

124. *(a)* In a pathology laboratory steam is essential only for sterilizing media and apparatus and rendering discarded materials safe. Where a suitable mains steam supply is available it may also be convenient to use it for heaters on the ventilating air supply plant as well as for heating and hot water supply plant, although all of these functions can be performed by alternative means.

(b) Each 300 litres autoclave will need approximately 45 kg of steam per hour, at a peak flow rate of about 130 kg per hour, and at a pressure of not less than about say 3 bar. Steam generators will be necessary to serve the autoclaves where a suitable mains steam supply is not available. Some autoclaves are available with steam generators built integrally with them; alternatively, separate free-standing steam generators may be used. A typical unit intended to supply one 300 litres autoclave would be rated at 18kW, requiring a 3 phase supply and would be 600 × 990 × 2010mm high. All electrically heated units, whether built-in or free-standing, should conform to British Standard 3970–Part 5 (or British Standard 1894 in the case of units above 36 kW loading). These steam generators produce steam at a higher pressure than that used in the autoclave and rely on their storage capacity to provide for the maximum demand of steam when the autoclave and load are cold. The electrical loading of the generators is intentionally limited to minimise the effect of the electricity supply system and a recovery period may be necessary between cycles on the autoclaves. At least two steam generators should be provided, with inter-connections so that a limited service can be maintained during breakdown or maintenance. The manufacturer's advice should be sought about the lowest electrical rating of the unit(s) which will provide a satisfactory service under the operating conditions to be expected. Gas heated units may be more acceptable on some sites though they can be rather noisy. Steam generators must be fed with water of a suitable quality if they are to operate reliably. If a supply of soft water is available this will usually be satisfactory, in other cases some water treatment is essential. A suitable blow down pit or receiver must be provided.

Gases, compressed air and vacuum

Town or natural gas

125. Although there is need to reduce the number of outlets of flammable gases to the barest minimum, for example by the use of electrically heated water baths, incubators, ovens, stills etc. it is not possible to dispense with the bunsen burner. These are required mainly in microbiology for heating inoculation loops and the rims of tubes and flasks with sterile contents; they are also required in virology for phage typing machines. Each fixed item of equipment heated by town or natural gas should be connected via a safety cock of the drop-lever or similar type and fixed pipework using screwed union connectors as necessary. Town or natural gas supplies to bench apparatus such as flame photometers should be connected in a similar manner but unions will invariably be required at the cocks. Outlets for any bunsen burners which are used very intermittently and in any fume cupboards may be of the serrated nose push-on type and each must be controlled by a safety cock. Normally gas outlets should not be provided inside a microbiological safety cabinet but, where they are deemed essential for the work the gas supply in the cabinet must be via a solenoid valve that will allow gas to pass only when the fan is switched on and that needs to be manually reset after any interruption of the current. If bayonet connections are used it is necessary for all burners to have

screw-thread connections. The following scale is recommended:

TABLE 11

Accommodation	*Scale*
Microbiology and P.H.L.S.	1 twin outlet per 1·5m bench length
Fume cupboard and micro-biological safety cabinet . .	1 twin outlet (situated outside microbiological safety cabinets)
Office/laboratories	1 twin outlet
Mechanised section (haema-tology and biochemistry) . .	1 outlet
All other laboratories	1 twin outlet per 6m bench length
Workshop	1 outlet

Compressed air supplies

126. *(a)* Compressed air is likely to be used for flame photometers for drying purposes in some glassware washing machines, for driving small pumps and for minor drying and cleaning purposes. Compressor plant operating at say 3 bar is likely to be adequate for all laboratory requirements provided it is fitted with a large air receiver which will enable it to meet the intermittent demand for large quantities of air without causing serious fluctuations in mains pressure. The air must be oil-free. Typical requirements are:

TABLE 12

Equipment	*Pressure required Bar*	*Flow rate required at STP. Litres per minute*
Flame photometer	1·4	20
Glassware drying machine	2·8	85
De-ionizing plant	0·4	60

(b) In addition to specified outlets for the items of equipment the following general scale of outlets is recommended:

TABLE 13

Accommodation	*Scale*
Chemical pathology—steroids/ chromatography	1 outlet per fume cupboard or hood
Chemical pathology—toxi-cology/chromatography	1 outlet per fume cupboard
Chemical pathology—chemical preparation bay	2 outlets on wet preparation bench
All other laboratories including mechanised section	1 outlet per 12m bench length
Workshops	1 outlet
Office/laboratories	Nil

127. The plant should comprise two sets, each of full capacity, operating on a ''duty'' and ''standby'' basis with manual changeover. The air should not be taken from the general ''hospital'' compressed air supply because of the risk of contaminating the latter. It is not essential to dry the air but an after-cooler fitted with an automatic trap and manual drain valve will reduce condensation in the distribution system to a minimum. An automatic trap and manual drain should also drain the air receiver. The main runs should be laid to a fall and be fitted with drains and traps. Each trap should have a visible discharge into a gully. A dry type filter capable of removing 95 per cent of all particles of 5 micron size and a silencer should be fitted on the intake. The filter will usually be located in the plant room because of the comparatively small capacity of the compressor. A flexible connection should be used to connect the compressor installation to the fixed distribution pipework so as to prevent the transmission of plant room noise along the pipeline. Individual filters and moisture traps may be fitted at supply outlets where essential because of the type of apparatus to be connected. For the purpose of calculating compressor requirements the first general bench outlet should be assumed to require 80 litres per minute at STP and all other bench outlets 20 litres per minute. A pressure-gauge and safety-valve (discharging to a safe position) should be provided on the low-pressure side of all pressure regulators and reducing valves.

Rough vacuum

128. Rough vacuum of minus 530 mb to minus 670 mb is sufficient for most laboratory work, such as removing air and fluids from waxed tissue, evacuating anaerobic jars, filtering, for example through Grade 5 sintered filters, as well as for transferring fluids from containers. It should not be obtained from the general hospital medical vacuum installation because of the risk of contaminating the latter. The pathology laboratory system may entrain solvent gases and possibly acid vapours, which might result in damage to conventional vacuum pumping plant. Water-sealed vacuum pumps with casings, impellers and air vessels designed to cope with these contaminants may be used, but all conventionally lubricated pumps may be unsuitable unless they are specially designed for laboratory vacuum work and can cope with the solvent gases and acid vapours. Drain traps, with isolating valves, should be provided on each bench spine connection. Bacterial filters should be fitted in parallel and preferably sited between main sanitary traps in the plant room and the vacuum reservoir. The filters should have a penetration not exceeding 0·05 per cent when tested by the sodium flame test in accordance with British Standard 3928.

129. The cold water mains supply should not be used to operate water jet vacuum pumps except where there is no safe alternative. It may be necessary to use them in certain locations because of the risk of spontaneous combustion or explosion when certain substances are evacuated by a conventional piped vacuum system served by a vacuum pump. It may also be necessary when dealing with specially corrosive substances. This restriction on water operated pumps arises from the need to conserve water and because of the risk of contaminating the water supplies. Most local water by-laws forbid the use of these pumps.

130. The central vacuum pumping plant should comprise two sets each of full capacity on a ''duty'' and ''standby''

basis with a manual changeover. Each ordinary outlet should be capable of passing 30 litres of free air per minute when operating at a vacuum of minus 530 mb. Throttles should be fitted to general service bench outlets to reduce the flow to 6 litres per minute (or in some cases 20 litres per minute) so as to limit the size of the vacuum plant required. For the purpose of assessing plant capacity the first vacuum outlet should be assumed to require 30 litres per minute and all other outlets 6 litres per minute of free air.

131. The exhaust gases should be discharged outdoors above roof level of the pump house and buildings in the immediate vicinity and away from windows and other air intakes.

132. The following scale of vacuum outlets is recommended:

TABLE 14

Accommodation	*Scale*
Morbid anatomy	1 outlet per 4·5m bench length
Haematology and chemical pathology	1 outlet per 9m bench length
Microbiology and P.H.L.S.	1 outlet per 18m bench length
Mechanised section	2 outlets
Workshop	1 outlet
Office/laboratories	Nil

This Building Note does not cover the provision of a very high vacuum service such as may be required for freeze drying equipment. If such a service is required it would be provided by portable high vacuum plant or by plant incorporated in the apparatus itself.

Gas cylinder management

133. *(a)* Care is required in the selection of locations for the storage of the various cylinders of gases which are actually required for use. Proximity to fire exits should be avoided. If empty cylinders are to be kept in the store, as well as full ones, the empties should be kept in a separate section clearly marked for empty cylinders only. No artificial heating should be provided in the gas-in-use store except that the manifolds (where used) may be electrically heated to the maker's standard design. The lighting fittings and switches in the room should be flameproof, of a type complying with British Standard 229. Cylinders in use should be held securely in purpose-made racks; where appropriate these may be designed on the lines of those used for hospital medical gas installations. Spare cylinders may be held either in the gas-in-use store or in a separate store. The racks for the spare cylinders may either be purpose-made or made on the lines of that illustrated in British Standard 1319. Reference should be made to Hospital Technical Memorandum No. 16: Fire Precautions, for guidance on the storage and handling of gas cylinders, in particular it should be noted that oxygen should not be stored in the same room as flammable gases.

(b) The supply to the apparatus or bench outlets should be piped from the gas-in-use store. This arrangement may not be necessary in the case of some of the special oxygen/carbon dioxide mixes which are themselves non-flammable and which may be used in only very small quantities. Extreme care is required in the piping of hydrogen. (See British Standard 3202.)

(c) Where a fire detection system is provided, detector heads should be fitted in any flammable gas store forming part of the main building.

Drainage

General

134. Effluent discharged from a pathology laboratory may be highly pathogenic and should therefore be kept separate from the rest of the hospital drainage system, particularly the drainage for those departments where extra care must be taken, such as operating theatres, I.T.U. and kitchens, until it is well outside the precincts of the main hospital. Pathology drainage can also contain a considerable chemical content, and should therefore be designed to give maximum dilution. The designer should familiarise himself with the types of effluent produced by specialist equipment and the effect that the mixing of the various chemical discharges may have upon the drainage systems linked to the pathology department. Provision should be made for future additions to the system (e.g. in the biochemistry department, where the mechanised content is high) by the strategic placing of blanked-off swept junctions. Drainage from the laboratory should not be installed close to water supply pipework, either buried or within ducts; water supply pipework can be subjected to reduced or reverse pressure either through poor design or an abnormally high demand in one part of the building, or through a mechanical break in the line. Contamination could occur of an assumed pure water supply if there is, within the water distribution layout, any leaking joint close to a faulty drain. Consequently, water supply pipes contained with drainage pipework within a horizontal duct should always be fixed *above* the drain. Water supply pipes buried in the ground should be placed above the drain and at least 1·0m to one side. Where this is not possible the water supply pipe should be surrounded in granular material of the single particle size (min. 10mm) and laid with as few mechanical joints as possible. There will need to be compliance with the requirements of the relevant Public Health Act and the appropriate statutory authority must be made aware of the type of effluent likely to be discharged.

135. Drainage pipework contained within ducts should be inspected at regular intervals and located where easy access for inspection and maintenance is possible. Access for cleaning should be provided in positions which will result in the minimum of disturbance to laboratory staff and, where possible, above the appliance flood level, e.g. above rim level of the appliance so that the spillage of contaminated effluent can be minimised. Autoclaves (except those used for the decontamination of infected material), glassware washing machines and refrigerators should not be connected directly to the drainage system but should have some form of air gap to prevent the ingress of bacteria. The sterilizer for discarded material must be connected to the drain via a vented break

tank and trap. The break tank should be vented outside the building, the vent terminating above roof level clear of any ventilation inlet window etc. The trap should be positioned between the break tank and connection to the drainage system. Any trap or gully is a miniature septic tank where bacteria can develop. If a blockage occurs in a horizontal drainage system, sewage will back-up into the nearest sanitary appliances or gully before it becomes obvious to the staff. These appliances and/or gullies can therefore become contaminated and should be flushed out after the blockage has been cleared. Gullies should, wherever possible, be omitted or reduced to a minimum. If they have to be installed a proper system of planned maintenance should be adopted, including topping up and disinfection. Where gullies have to be installed as a possible means of disposing of over-flow water, they should be fitted with gasketed screw-down cover plates which can easily be removed if required. Gullies should have a minimum of 50mm between their grating and any waste outlet emptying over them.

Materials for and design of pathology laboratory drainage systems

136. *(a) General*

Metal pipework is not, in general, suitable for use in pathology laboratories, either for branch drains servicing individual sinks or equipment, or for any other local position where a blockage could result in an aggressive effluent backing up. In particular, copper and lead have given trouble with effluents containing either azide or mercury compounds. Glass, poly-propylene, acrylonitrile butadiene styrene (ABS), modified polyphenylene oxide (Noryl) and high density polythene can all give good service, depending on the chemical characteristics and temperatures of the fluids discharged and the arrangements for fixing and supporting the drain.

(b) Glass installations

Glass pipework for both waste and drainage is available in all sizes up to 150 mm and is suitable for the handling of all types of chemical effluent likely to be met in pathology laboratories, as well as boiling water from sterilizers. All the necessary components (including catchpots) are available for a system from the equipment to the sewer. The installation requires special techniques and should be carried out by the supplier; it is therefore not easily replaced or altered by the hospital staff. The jointing system is mechanical and allows for considerable differential movement, thermal expansion is not a problem; the material is brittle and hangers, fixings etc., should be supplied and installed as part of the same contract.

(c) Polypropylene and other plastics installations

(i) Most of these plastics are chemically inert, with certain specific exceptions for each material; e.g. with polypropylene certain aromatic solvents (benzine and chloroform) cause distortion, swelling and/or softening. In the case of automatic analysers the deleterious effect of the waste on the plastic can be minimised by the use of a dilution chamber. In other cases, waste solvents with such properties should be separately collected and disposed of by other means. Since polypropylene and other plastics are flammable and thus add to the fire load their use may be subject to restrictions by the Fire Officer. It is understood that plastics with suitable fire retardants added are available abroad and may shortly be available in the United Kingdom.

(ii) Plastics waste systems are of two types, those with mechanical joints and those with fusion welded joints (solvent welding is not acceptable for laboratory drainage systems). Mechanical joints are of the compression type relying on the seal due to a feathered edge or olive to achieve pressure tightness. In certain cases, joints using "O" rings may be used. Fusion welded joints are formed by heating a "tool" which is then used to fuse the two stubs, which, when pressed together, form a homogeneous joint.

(iii) Drainage systems in plastics materials will need to make adequate provision for thermal expansion, which can be relatively high (at 20°C the coefficient of thermal expansion for polypropylene is $1{\cdot}10 \times 10^{-4}$ per degree C, this is equivalent to a change in length of 7·2 mm in a 6 metre pipe per 10°C rise). Fixings should be of a type that allow thermal movement to take place, both in the main drain and in the various branches of the system. Some manufacturers of these plastic drains systems do not carry out the installations but they should always be asked to advise on the design and spacing of fixings. For polypropylene, the distance between fixings at 20°C should not exceed:

Nominal Bore	*Horizontal*	*Vertical*
32— 40 mm	0·75 m	1·50 m
50 mm	1·20 m	2·50 m
75—100 mm	1·80 m	3·50 m
150 mm	2·50 m	4·80 m

For temperatures up to 65°C the centres of fixings will need to be reduced and above this temperature continuous support is recommended.

(iv) Plastics pipework should not—with the possible exception of "Noryl"— be used where a continuous discharge of very hot effluent is likely. In the case of sterilizers, where the discharge of boiling water at full bore is intermittent, the plastics listed can all be used.

Testing drainage systems

137. Testing of the drainage systems should in general be carried out in accordance with British Standard Code of Practice, CP 304 (1968); in the case of all horizontal suspended drain lines a hydraulic pressure test should also be applied, to a value corresponding to that occurring when the lower end of the system is blocked.

138. Waste disposal units should be connected in accordance with the maker's instructions. The waste from the unit should not be connected into a side or back inlet gully. The waste runs need careful planning. Longsweep bands should be used and the entry into the main line should be taken at an acute angle. The junction should not be made in the form of a cross and the connection should be made into a main which is regularly flushed at full bore, e.g. down-stream of a WC or bath. These drainage runs should not be installed above hot pipes.

Hot room

139. This will be a well insulated room having an internal floor area of approximately 10m². A larger room will be required in a joint area/P.H.L.S. laboratory. The door should be openable from the inside. Heating may be provided by the use of industrial fan heaters with a high air velocity discharge, fitted at high level within the room and controlled by a duct type thermostat. A second, upper limit, thermostat should be provided to prevent a dangerous temperature being reached due to failure of the main thermostat. If the heater has an electric element it should be rated at not less than 4 kW. Alternatively, heating may be provided by thermostatically controlled low temperature heaters, shielded to prevent articles being placed in contact with them. A ceiling mounted variable speed fan will prevent stratification, the fan control should be interlocked with a door switch so that the fan is stopped when the door is opened. A further alternative is heating by thermostatically controlled fan-assisted electric convectors. A temperature of 37°C±2°C must be maintained. A recording thermometer visible from outside the hot room must be provided.

Cold rooms and blood bank

140. These will be well insulated rooms. The main cold room should have an internal floor area of approximately 15m². Another cold room with an internal floor area of approximately 7m² should be provided. The normal operating temperature of the main cold room is 4°C to 6°C. It is used mainly for the storage of media plates. The normal operating temperature of the second room should be between minus 20°C and minus 25°C. These cold rooms need not necessarily be on the same floor. The minus 20°C room may open off the 4°C room. The minus 20°C accommodation may alternatively be in the form of top opening cabinets.

141. The main blood bank should have an internal floor area of approximately 6m² and should be designed generally in accordance with British Standard 4376. The normal operating temperature of the blood bank is 4°C to 6°C. Each cold room and blood bank must have a recording thermometer fitted outside the room. An alarm system should be incorporated in the blood bank with the alarm bell outside the room and repeated at the telephone exchange (or other premanently manned station) to give a warning if the temperature rises above 8°C or falls below 2°C. A flashing light signal should be provided to indicate when the doors of cold rooms (and hot rooms) are open.

142. Free-standing deep freeze cabinets, some operating at minus 70°C, and free-standing blood bank cabinets conforming to British Standard 4376 may be provided additionally as loose equipment. Larger cold rooms will be required for a joint area/P.H.L.S. laboratory.

143. *(a)* The refrigerating plant for the cold rooms and the main blood bank should be housed in a well ventilated chamber with natural ventilation. It should be fitted on anti-vibration mountings and on a high plinth to facilitate servicing. The direct expansion cooling coils should have suitable drainage trays led to waste. The refrigerant should be non-toxic. Drainage runs must be carefully sited and must be heated if necessary to prevent freezing-up during the defrosting procedure. Automatic defrosting should be provided, with the fan switched off during the defrosting procedure. Alternatively, built-in and purpose-made chillers may be used provided they meet the general requirements as above.

(b) A ceiling-mounted fan should be provided in each cold room to prevent stratification. The fan control should be interlocked with the door switch so that the fan is stopped when the door is open. A plain neon light or illuminated sign should be fitted outside each room, to indicate that the circulating fan is running.

(c) The construction and insulation of the rooms should ensure that the total running time of the plant does not exceed 18 hours per day with normal room usage, with an external ambient temperature of 20°C. Door fastenings should be operable from inside the rooms as well as from outside. The fan control should stop the fan when the door is open. A white neon light or sign should be fitted outside each room to show that the circulating fan is running. Fittings in the room should be galvanised; the lighting fittings should be water-tight with their control switches inside the rooms.

Sterilizers

Laboratory autoclaves

144. These are normally single ended, manually operated, downward displacement autoclaves having horizontal rectangular chambers without jackets and working at a steam pressure which can be manually varied up to 2 bar so that the temperature may be varied between 100°C and 134°C. They should conform to British Standard 2646 which is currently under revision. Pending publication of the revised edition their materials, general construction, safety features, intrumentation and thermal insulation etc. should be in accordance with the various parts of British Standard 3970 where relevant. Reference should be made to Health Technical Memorandum No. 10: Sterilizers for guidance on purchase and installation. If the autoclaves are to be built-in this should be stated in the specification, as should any special requirements or features such as special fitments in the chamber, baskets or trays required, vacuum pump, condenser, recording thermometer etc. Special steam trapping arrangements incorporating by-passes are necessary if the machines are required for media preparation at low pressure. Machines having chambers of 300 litres capacity will usually be suitable. They will require a supply of steam at about 3 to 4 bar and will create a peak demand of the order of 125 kg of steam per hour. A suitable water supply will also be necessary if steam is to be generated locally or if the machine incorporates a vacuum pump or condenser.

Dry heat sterilizers

145. These are normally free-standing but if the steam sterilizers are to be built-in it may be convenient also to build in the hot air sterilizer, on the lines indicated in Health Technical Memorandum No. 10: Sterilizers. Their performance must comply with British Standard 3421.

Laboratory glassware washing machines

146. These should preferably be of a type which can wash the insides and outsides of test tubes, bottles and flasks simultaneously. It may be an advantage if they can also wash pipettes. Machine cycle controllers should be fitted with adjustable timers and the machines should preferably have automatic dispensers for softener, detergent and wetting agent. Provision should be made for a thermostatically controlled drying cycle, either in the same machine or in a matching drier. Two washing/drying machines are required and each should be complete with three sets of carriers for each type of glassware. Machines employing water jet pipes which traverse above and below the articles may give equal results for many types of glassware but may not remove adherent material in the base of some flasks and similar vessels having a neck much narrower than their base.

Waste disposal

147. It is assumed that large items for disposal will be bagged and destroyed in the hospital incinerator. A free-standing waste disposal unit, complete with integral pump and permanently connected to the drainage system via a trap, should be provided in the formalin store and another in the specimen cutting area in the morbid anatomy laboratory. Facilities for pressurised flushing and washing of the hop' r should be incorporated. Machines with 3 hp (2 kW) m ors and 200mm cutters will be suitable for most laboratories. Small kitchen waste disposal units are unsuitable for these services. All infected waste must be autoclaved before disposal. If faecal cartons of a ''waxed cardboard'' type are used a unit with 150mm cutters should be provided adjacent to the faecal fats fume cupboard in the chemical pathology department. Each machine should be supplied with cold water from a sanitary system break tank. Care should be taken to flush the waste system thoroughly after disposing of solids through the units. When, because of contamination or for other reasons, it is necessary to dispose of highly flammable liquids, this is probably best done by burning them in a suitable open, shallow, metal container in the open well away from any building, flammable materials store or drains. Waste fluids which are not miscible with water should be burnt if possible or handed over to the Local Authority for disposal. Waste mercury and waste cyanide should be handed to the Local Authority for disposal. Strong acid and alkali solutions should be diluted before they are poured away. Metal materials should not be used in the construction of the drainage system for the sinks in a pathology laboratory. (See also paragraph 134 on ''Drainage''). Slop-hoppers are unnecessarily expensive; low level sinks will usually be satisfactory for the purpose and should be provided for waste disposal in the specimen receipts area, the disposals area and the cleaners' room.

Catering equipment

148. No catering equipment is required in the duty room. An electrically heated, automatic and thermostatically controlled water boiler may be provided in the staff room if this is some distance from the staff restaurant. A pressureless boiler, capable of producing 72 litres of boiling water per hour, with pre-heating and providing not less than 18 litres available in ten minutes will usually be adequate. Alternatively the installation of an automatic vending machine may be considered. A domestic refrigerator, used solely for culinary purposes, should also be provided.

Fire protection system

149. Reference should be made to Hospital Technical Menorandum No. 16: Fire Precautions and in particular to Appendix V—Fire Protection in Laboratories; see also paragraph 160 of this Note and Hospital Design Note No. 2: Protection Against Fire.* The Chief Fire Officer of the local fire authority should be consulted in the early stages of planning. Pipe work and steel work in the vicinity of pipes carrying flammable liquids or flammable gases should not be painted with aluminium paint.

Pneumatic tube communicating systems

150. These systems are unlikely to be appropriate for pathology laboratories. Further information on this subject is contained in Hospital Technical Memorandum No. 9: Pneumatic Tube Communications Systems.

Electrical Services

General considerations

151. Guidance on factors affecting the supply and distribution is available in Health Technical Memorandum No. 7: Electrical Services Supply and Distribution, and Hospital Technical Memorandum No. 14: Abatement of Electrical Interference. The electrical installation should comply with the Regulations for Electrical Equipment of Buildings issued by the Institution of Electrical Engineers.

Electricity supply and distribution

152. The supply will normally be provided by sub-main circuits from the main intake and distribution centre to one or more switchgear rooms within the department. Local distribution boards should be in well ventilated positions, preferably accessible from corridors. The installation should be designed to promote the flexible use of the laboratory. Longitudinal trunking and conduit runs should have sufficient capacity to accommodate any cable likely to be required in the future. Any external conduit, cables and fittings should be in weatherproof construction. A lock should be fitted to any distribution board not located in a switchgear room. It is an advantage if the boards can be reached from a standing position. High rupturing capacity fuses are recommended for general use. Spare ways and fuses should be provided for local extensions and space should be allowed for future additional circuits to meet the increasing use of electrical apparatus in the laboratory. Miniature circuit-breakers conforming to British Standard 3871 are sometimes preferred for circuits supplying bench outlets. Special sub-circuits may be needed for the larger centrifuges to overcome the difficulty due to surges on starting.

153. It is intended that all laboratory apparatus which is susceptible to interference by connection to unsuppressed mains will (probably by 1980) be fitted with interference suppression filters (suppressors). In the meantime, the conduit layout should be arranged so as to permit the insertion

*New departmental guidance on Fire Safety will be contained in Health Technical Memorandum (HTM) 81 entitled 'Fire Safety in New Health Buildings' which is the forerunner of a series of fire documents currently in preparation.

of suppressors if these are found to be necessary. A 30 amp suppressor measures approximately 400mm × 180mm. One of these suppressors will be required for each ring circuit. The conduit should enter at one end and leave by the other end of the filter. (See Hospital Technical Memorandum No. 14: Abatement of Electrical Interference.)

Artificial lighting

154. *(a)* Fluorescent lighting should be used generally except in any storerooms etc., where lighting is used for exceptionally short periods. In clinical and certain laboratory areas, including associated circulation spaces, colour identification may be important and specially selected fluorescent lamps will be required. Lamps in these areas should meet the chromaticity and colour-rendering requirements of the Medical Research Council's Report No. 43, dated June 1965. In such areas the colour chosen for walls and ceilings should be carefully considered. Architects and engineers must co-operate in this task to ensure that the decorative finishes are compatible with the colour-rendering properties of the lamp and that the spectral distribution of the colours of the primary light source is not unduly altered.

(b) Special attention should be paid to the reduction of glare from fittings in blood transfusion rooms and patient examination rooms where patients in a supine position may otherwise suffer discomfort from glare. Lighting fittings should be selected and positioned to minimise glare and facilitate cleaning and maintenance, the latter points may present some difficulty in staircases. The stroboscopic effect of fluorescent lighting should be minimised where there is moving machinery by the use of twin tube fittings suitably adapted for this purpose or by the use of two phases for the lighting circuits in the room. The fittings should be sited to suit working conditions and to ensure that they are not liable to damage when windows or high cupboards are opened or where rolling type storage cabinets are used. General lighting may be controlled by local wall switches. Corridor and staircase lighting switch positions should be carefully selected.

(c) Special low-voltage circuits for microscope lighting should not be necessary since microscopes are normally provided with their own variable-ratio transformers either integral or as separate items.

(d) In certain areas it is necessary to augment the lighting at bench level and, in other areas where colour rendering or close work is involved, adjustable lighting fittings will be required, for example, one adjustable fitting will be required over each microtome and one for each technician in the staining and blood technology section and serology section. Fittings selected for this service should be of a type unlikely to require excessive maintenance.

The following scale is recommended:

TABLE 15

Accommodation	*Scale*
Morbid anatomy—	
generally	1 per 4·5m bench length
section cutting	1 per 1·5m bench length
staining	1 per 1·5m bench length
Haematology P.H.L.S.	1 per 3m bench length
Microbiology	1 per 3m bench length
Patient examination rooms	1 medical type per room
Workshops	1

(e) Lighting for safety cabinets and fume cupboards should be provided by fittings behind toughened glass panels which are sealed at the edges to exclude vapour and fumes or by suitable vapour-proof fittings within the cupboard. Lighting fittings in hoods should be protected against vapour and fumes. Lighting fittings in the steroid and gas chromatography areas should be gas tight and their control switches should be away from the working areas and fitted with a pilot light if necessary.

(f) The recommended levels of illumination at working level are:

TABLE 16

Accommodation	*Average value of illumination*	*Limiting glare index*
	Lux	
Laboratories, office/laboratories, isotope source store, fluorescent microscopy, outfit preparation, wash-up and sterilizing room, workshop	250	19
Lecture room/museum/library, patient examination	200	16
Reception, general office and records, duty room	150	19
Staff, disposal, hot, cold, blood bank, switchgear, plant rooms	100	
Staircases and corridors	100*	
Entrance and waiting areas, stores	80	
Cleaners' rooms, lavatories, changing rooms	60	

*The standard required is at floor level.

If the building is of deep-plan design the above levels of artificial illumination should be increased only in the accommodation shown in the table below for rooms which are in the core area and are without natural light.

TABLE 17

Accommodation	*Average value of illumination*	*Limiting glare index*
	Lux	
Reception, general office and records	250	
Hot, cold, blood bank, waiting areas	200	
Stores	150	
Cleaners' rooms, lavatories, changing rooms	100	

The illumination levels of any corridor connecting naturally lit rooms with the arificially lit core rooms should be increased in deep-plan designs to 200 Lux.

Power supplies

155. *(a)* All fixed apparatus should have efficient means of isolation easily accessible to the operator. Isolating switches should be provided adjacent to extract fans where necessary for the safety of maintenance staff.

(b) Sufficient general purpose 13 amp standard switched socket outlets on ring or spur circuits should be provided to allow each portable appliance which is likely to be used simultaneously to be connected to a separate fixed outlet. Many of these outlets will be used for electronics apparatus, each ring circuit for bench sockets may therefore supply say 50m² of floor space, or about 30 socket outlets. Outlets should also be provided at convenient points for the use of floor maintenance appliances, on the basis that the flexible leads from these are unlikely to exceed 9 metres in length.

(c) In main laboratories a cable trunking system is preferred and this is incorporated in the bench spine or partition wall, with the socket outlets fixed to the trunking lid. This gives sufficient flexibility and allows re-positioning and addition of outlets with the minimum of disturbance. Fixed equipment requiring less than 13 amps may be permanently wired from fused spur boxes. Equipment rated at more than 13 amps should be supplied from separate final sub-circuits and must be independently switched. Spur units to be used for remote fans should be fitted with neon type indicating lights, non-luminous heating appliances and small appliances should be fitted with indicating lights to indicate when the supply is connected to them.

(d) The following *minimum* scale of socket outlets is recommended:

TABLE 18

Accommodation	*Scale*
Laboratories (general)	2 twins per 1·5m of bench length
Mechanised section	4 twins per 1·5m of bench length
Office/laboratories	Benches—as for general laboratories plus 1 twin for desk
Reception, general office and records	10 singles
Patient examination, venepuncture	2 twins
Staff room, duty room	1 twin
Workshop	3 twins
Fluorescent microscopy	2 twins
Lecture room/museum/library	2 twins
Hot, cold, blood bank, plant rooms	1 single
Fume cupboards	See Appendix 2
Corridors and waiting area	Scale of provision to allow use of floor cleaning appliances having flexible leads assumed to be not more than 9m long.

(e) Socket outlets should not be installed within fume cupboards unless the socket outlets are of the flame-proof type.

Emergency electricity supplies

156. Emergency electricity supplies should be generally in accordance with Hospital Technical Memorandum No. 11: Emergency Electricity Services.

(a) Socket outlets

Every socket outlet in the working area should be connected to the "essential" supplies circuit. It is reasonable to assume that only essential equipment will be used in these areas during periods of supply interruption. This arrangement secures economy in the capital cost of the installation and provides the most convenient choice of socket outlets for use at any time.

(b) Emergency lighting

Grade *(a)* lighting should be provided in essential working areas, e.g. blood banks, transfusion laboratories;
Grade *(b)* lighting should be provided in general waiting areas.

Telephones

157. *(a)* The advice of the local Telephone Manager can be sought, if required.

(b) The hospital telephone system should extend to the area pathology laboratory and the P.H.L.S. laboratory and extensions will normally be provided in reception and general offices, duty room, each office/laboratory and each chief technician's office. One or more extensions will usually be required in each general laboratory area. Extensions will also be required in those laboratory areas dealing with urgent and emergency tests and in addition may be required in media preparation, P.H.L.S. virology, research laboratories and lecture rooms.

(c) Where automatic exchanges are provided, it is possible to bar extensions from access to trunk lines and with the advent of STD it may be advisable to consider the means of preventing unauthorised trunk calls. The trunk line barring required in the pathology laboratory differs from that in the P.H.L.S. laboratory because of the difference in the sizes of their respective catchment areas. The capital and revenue charges arising from trunk barring equipment should be considered against the expected savings on trunk call charges. This problem does not arise with manual exchanges.

(d) In the P.H.L.S. laboratory filtering of calls is also required and this can be achieved by the use of an appropriate GPO House Exchange system, probably not exceeding a "1 plus 5" which allows five telephones in the department. The director should also have an independent telephone in any case.

(e) A pre-payment coin operated dial telephone should be provided in a suitable position for the use of patients and for staff to make private calls. This should be connected direct to the public exchange.

Intercommunication system

158. (a) There may be advantage in having direct intercommunication between the operating department and the morbid anatomy laboratory. This should be an extension to the system installed in the operating department.

(b) A monitored loud-speaking telephone or equivalent to permit "hands-free" operation may be required from the pathology department to the mortuary.

(c) Trials designed to test the suitability of facsimile telegraphy (F/T) equipment for the transmission of pathology reports from the laboratories to the wards are referred to in Hospital Technical Memorandum No. 18: Facsimile Telegraphy—Possible Applications in District General Hospitals and Hospital Technical Memorandum No. 19: Facsimile Telegraphy—the Transmission of Pathology Reports within a Hospital—a Case Study. They show that the use of F/T equipment in place of an effective messenger service for the return of pathology reports to wards, although costing substantially more, provides no more than a tenuous benefit to patients. (See also paragraph 150).

(d) Intercommunication systems with conference facilities, e.g. loud-speaking telephones, may be needed to enable heads of departments to communicate with each other and with their chief technicians and general laboratory staff.

Staff location systems

159. The hospital staff location system should be extended to this department. See Hospital Technical Memorandum No. 20: Staff Location Systems.

Alarm systems and fire detection systems

160. (a) An alarm circuit from the blood bank to an alarm outside the blood bank room and to the hospital telephone exchange or another continuously manned point should be fitted to operate as indicated in paragraph 141. Local flashing lights may be provided to indicate when cold room and hot room doors are open.

(b) Provision must be made for the special security of dangerous drugs, poisons and drugs liable to misuse, stored within the department in accordance with current requirements, statutory or otherwise. The contents of HM(70)1 on the Security of Drugs Liable to Misuse should also be noted.

(c) There is a particular danger of fire, arising from the regular use of highly volatile solvents in the laboratory. The hospital fire alarm system should cover the laboratory. The need for an automatic fire detection system should be considered, particularly in rooms which are not occupied at night or for long periods and which contain equipment constituting a special fire risk. Automatic fire detectors should be installed to cover the whole area of any room in which electrical equipment is left connected to the supply during non-working hours. The detectors should be wired to an indicator in the hospital telephone exchange or another continuously manned fire control point. If an automatic fire detection system is installed it should cover the gas-in-use store and the spare gas containers store if these hold flammable gases. Advice on fire detection, alarm and fire fighting installations is given in Hospital Technical Memorandum No. 16: Fire Precautions* and advice should also be sought from the Chief Fire Officer of the local fire authority.

Clocks

161. It is difficult to specify the exact number of electric clocks to be provided for any particular laboratory, as it will depend to a great extent on the building lay-out. In many cases, the number can be reduced by providing clocks at strategic positions in corridors. It is unlikely that more than 20 clocks will be necessary for an area laboratory. This number would include clocks in some of the individual laboratory rooms, such as blood transfusion, toxicology, virology, serology, Category B1 room and media preparation, as well as those in the waiting area, general office, consultant's office/laboratories, staff duty and rest rooms and general laboratories. Clocks in the serology area should have sweep second hands and similar provision may be made for clocks in the laboratories. Synchronous or battery clocks should be used, unless the hospital already has an impulse clock system which can be extended. Where sweep second hands are required a local AC "essential" supply should be taken to feed a synchronous movement within the same clock. Where

*New departmental guidance on fire safety, detection and alarm systems is currently in preparation.

possible advantage should be taken of the savings to be made from suitably sited double-faced clocks. Clock dials should be plain and non-reflective, with simple numerals rather than symbols.

Goods lift

162. In multi-storied buildings, where a centralised wash-up and sterilizing room is proposed, a general duty goods lift would be required to transport glassware in trolleys etc. and a 500 kg goods lift to British Standard 2655 will be adequate for this vertical traffic. This lift should not communicate with any other part of the hospital because of the hazard of contamination from infected material.

Plant space and plant rooms

Sterilizers

163. It is sometimes found desirable to locate the ''dirty'' autoclaves remotely from the ''clean'' autoclaves, although they may all be in the same room (probably the wash-up/sterilizing room). The area required for a single steam autoclave is approximately $9m^2$. The area required to house two steam autoclaves and one hot air sterilizer is approximately $18m^2$. These can often be built-in with a single fascia containing the three machine doors. The area behind the fascia then becomes the plant room for the sterilizing plant and the space allowance is sufficient for sterilizing plant maintenance. (See Health Technical Memorandum No. 10: Sterilizers). This space must of course be properly ventilated because of the heat generated by the sterilizing plant and protected from frost in the silent hours. Additional space should be provided if separate steam generators and water treatment are to be installed. The area required will be approximately $6m^2$ per plant.

Gases-in-use stores

164. The room should be at ground floor level and if not separated from other buildings should be located against an outside wall with direct access to the open air. Combustible industrial gases should not be stored in the same room as oxygen or other medical gases. Fire prevention advice is given in Hospital Technical Memorandum No. 16: Fire Precautions—Part VIII. Some Chief Fire Officers insist on the flammable gas store being a separate building.

Cold room and blood bank refrigeration plant

165. An area of approximately $2m^2$ will be needed for this plant even if the chillers are built into the cold rooms.

Purified water plant

166. This plant should be housed *inside* the department, preferably in a room above the wash-up so as to ensure an adequate head of water from the de-ionized water storage tank to the washing machines. The de-ionized water storage tank itself should be placed as high as possible in the room but adequate access to the top of the tank is essential. A storage tank of 1,000 litres capacity will probably be adequate and the floor space required for the plant alone (excluding the tank) will be approximately $1{\cdot}4m^2$.

Ventilating plant

167. The ventilating plant will, in most instances, be in two separate rooms, one housing the supply air fans, silencers and air filters and the other housing the normal extract fans and silencers as well as the toxic extract fans and silencers. Such an arrangement may be necessary in order to ensure that extract air, flammable or noxious fumes and acid vapours are not passed into the supply air intake. The supply air equipment may require a room of approximately $18m^2$, the normal extract and toxic extract equipment may require a room of approximately $36m^2$.

Compressors and vacuum plant

168. The compressors may need approximately $20m^2$ and the vacuum plant approximately $13m^2$.

Switchgear rooms

169. Switchgear rooms or cupboards to house the main isolator and electrical distribution equipment should be located centrally to reduce the length of circuit wiring. The minimum recommeded size for each room is $2{\cdot}4m$ by $1{\cdot}5m$ to allow a clear passage in front of the switchgear. The dimensions will, however, depend upon the quantity and type of equipment to be installed. One switchgear room should be allowed on each floor. The room should be kept dry and well ventilated. The doors should be lockable but must allow an easy exit in an emergency.

Other plant

170. Accommodation must be provided as required for calorifiers and water storage tanks and, on some sites, for additional main switchgear and/or transformers.

V. Cost and other relevant information

Cost control

171. For cost control purposes the lump sum Cost Guide figures for the various functional units shown in the Departmental Cost and Area Guide (Hospital Building Procedure Note No. 6: part of CAPRICODE), will be applicable. These figures include basic accommodation together with circulation and an allowance in respect of additional accommodation and/or additional engineering.

172. Building Notes recommend the standards of accommodation and services for hospital departments which the Department of Health and Social Security consider it reasonable to provide. Health Authorities are at liberty to depart from the design recommendations given in Building Notes provided they are satisfied that the standards of accommodation and services they adopt are adequate. The Departmental Cost Allowance however is to be regarded as

the maximum sum available for a department requiring the basic services specified in this Note. Where (see e.g. paragraphs 8, 9, 10, 11 and 12), the hospital pathology department provides additional services on an area or regional basis (i.e. Public Health Laboratory services and/or reference laboratories) and additional provision has to be made for this, the cost allowance may be varied accordingly. Health Authorities are encouraged to produce designs for the provision of appropriate accommodation and services at a cost less than the Departmental Cost Allowance.

173. The pathology department Cost Guide figures provide for the basic and additional accommodation detailed in paragraphs 34, 35, 36 and 37 above and for the engineering services detailed in paragraphs 177, 178, 179 and 180 below.

Apportionment of costs

174. An assessment of the notional cost apportionment between the building and engineering service elements should be made at Procedural Stage C1 (Provisional Cost Plan—Hospital Building Procedure Note No. 1: part of CAPRICODE).

Circulation space

175. For the purposes of preliminary planning the area occupied by internal circulation space and internal walls and partitions represents, on average, and addition of 30 per cent of the net floor area of basic and additional accommodation.

Plant rooms

176. The plant room areas shown in paragraphs 163, 164 and 169 are included in the basic accommodation, those in paragraphs 165, 166, 167, 168 and 170 are regarded as communication space. All have been calculated for a single department scheme and some reduction in the areas should be possible in a multi-department development.

Engineering services

177. The following engineering services are included in the quoted cost of basic, supplementary and additional accommodation shown in the Departmental Cost Guide.

(a) Mechanical services

Heating	Low pressure hot water radiator system.
Ventilation	Supply to and extract from essential areas.
Hot and cold water services	From central supply, *not* including calorifiers and storage tanks.
Treated water	From local supply, including plant and storage tanks.
Steam and condensate	From central supply.
Town or natural gas	From central supply.
Compressed air	From local supply, including plant.
Oxygen	From central supply, *not* including plant.
Vacuum	From local supply, including plant.
Special gases	From local supply.
Fire fighting	Supply from rising main to hose reel points.

(b) Electrical services

Lighting (including fittings), socket outlets, all equipment wiring, wiring for mechanical services, clocks, standby services, distribution and sub-mains within the department, departmental switchgear, telephones, staff location, fire alarms and intercommunications.

(c) Equipment

Water boiler, fume cupboards, cold rooms and blood bank, sterilizers, glassware, washing machines and waste disposal units.

APPENDIX 1

Rectangular asbestos reinforced thermoplastic PVC laminate ducts

Length of side	*Minimum sheet thickness*	*Type of cross joint*	*Minimum sizes of angle flanges*	*Maximum spacing between joint/ stiffeners*	*Minimum section for intermediate stiffeners*
Up to 450 mm	2 mm	Spigot & socket	—	—	—
451 mm to 700 mm	2 mm	PVC angle flanges with mild steel backing flanges	40 mm × 40 mm × 4 mm PVC with 30 mm × 30 mm × 4 mm mild steel	1200 mm	40 mm × 40 mm × 4 mm PVC angle frame or 30 mm × 6 mm PVC flat, on edge, frame
701 mm to 800 mm	3 mm	ditto	ditto	800 mm	40 mm × 40 mm × 4 mm PVC angle frame or 40 mm × 10 mm PVC flat, on edge, frame
801 mm to 1000 mm	3 mm	ditto	45 mm × 45 mm × 6 mm PVC with 40 mm × 40 mm × 4 mm mild steel	800 mm	45 mm × 45 mm × 6 mm PVC angle frame or 50 mm × 10 mm PVC flat, on edge, frame
1001 mm to 1200 mm	3 mm	ditto	ditto	600 mm	ditto

APPENDIX 2

Suggested provision for microbiological safety cabinets, laminar flow cabinets, fume cupboards and fume hoods

Department and requirement	*Usable width (Metres)*	*Socket* outlets*	*Town or* natural gas points*	*Water points and drains*	*Special provisions*
Morbid anatomy					
2 hoods for dissecting bench	1·5	as required for equipment			*(d) (e)*
Fume cupboard	1·5	2	2	1	As required
Cytology					
Microbiological Safety Cabinet Class I	1·5	—	—	—	—
Haematology					
(Access to Class I safety cabinet)					
(Access to fume cupboard)					
Horizontal laminar flow cabinet (outflow) for packed red cells	1·2	2	2	—	vacuum *(a)*
Chemical pathology					
Microbiological Safety Cabinet Class I	1·5	as required			—
Fume cupboard (high velocity 0·9 m/s) for chromatography	1·2	2	2	1	air, vacuum nitrogen *(c)*
Fume cupboard for routine procedures	1·5	2	2	1	air, vacuum, *(f)* nitrogen
Fume cupboard for dispensing fluids	1·2	—	—	—	—
Hood for each flame photometer	as required for equipment				*(b)*
Hood for atomic absorbtion spectrophotometer	as required for equipment				*(b)*
Hood for muffle furnace	1·2	2	—	—	—
Hood for chromatography area	0·6	2	—	—	—
Hood for chromatography equipment	1·5	4	2	—	argon, compressed air, hydrogen, nitrogen
Category B1 room					
Microbiological Safety Cabinet Class I	1·5	2	as required		—
General Microbiology					
Microbiological Safety Cabinet Class I	1·5	2	as required		—
Virology					
Microbiological Safety Cabinet Class I	1·5	as required			—
Microbiological Safety Cabinet Class II	1·5	as required			—
Food Microbiology					
(Access to a Microbiological Safety Cabinet Class I)					
Hood	1·5	2	2	1	—
Media Preparation					
Horizontal laminar flow cabinet (outflow)	1·2	2	2	—	*(a)*
Specimen Reception					
Microbiological Safety Cabinet Class I (if required)	1·5	as required			—

**Socket outlets, gas points and other fittings should not be installed inside cabinets but provided adjacent to the cabinet for work associated with their need. GAS WILL NOT BE REQUIRED FOR 'FLAMING' LOOPS.*

(a) These operate by drawing air from the laboratory and discharging filtered air unidirectionally over the workspace. THEY DO NOT PROTECT THE OPERATOR.

(b) Hoods for flame photometers may need to be long to allow flexibility for use of space, but extraction rates should be related to volume of products of combustion with sufficient dilution of hot gases to minimise the amount of stainless steel ductwork required.

(c) May be shared between 'chromatography' and 'steroids'.

(d) Supply air should be ducted to the front edge of the bench and this can be used in conjuction with lateral exhaust slots, where appropriate, to provide the most effective means of ventilation in these cases.

(e) Alternatively, adequate ventilation of the whole room but *(d)* preferred.

(f) Fitted with water wash down sprays for ductwork and fume cupboard; ductwork to be self draining through base of fume cupboard with other drain points as necessary; the water supply to come from a break tank. All controls and services to be fitted outside the cabinet.

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